[COMMITTEE PRINT]

COMMERCIALIZATION OF LAND AND WEATHER SATELLITES

REPORT

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FOR THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

AND THE

SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT

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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., May 1983.

To the members of the Committee on Science and Technology:

There is transmitted herewith a report prepared by the Congressional Research Service entitled "U.S. Civil Remote Sensing Satellites: Commercialization Policy and Issues."

The proposal, advanced by the Administration, to transfer the remote sensing satellites to the private sector has aroused a great deal of interest because of the importance of the weather satellites to every person in the United States, and because of the potential commercial importance of the land sensing satellites. I think this document will provide very useful background for this issue, and I commend it to all the Members.

Sincerely,

DON FUQUA, *Chairman.*

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C. 20515

LETTER OF TRANSMITTAL

April 18, 1983

Hon. Don Fuqua, Chairman
Committee on Science & Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

We are transmitting herewith a report prepared by the Congressional Research Service at our request. The report is entitled "U.S. Civil Remote Sensing Satellites: Commercialization Policy and Issues". We requested the preparation of the report because we believe that this proposed commercialization will be an issue in this Congress and because it is complicated enough that substantial background information is needed to insure informed debate.

The report was prepared principally by Ms. Patricia E. Humphlett of the Science Policy Research Division.

The report contains an introductory discussion of the proposed commercialization and the associated issues, together with appended readings. Two of the readings should be noted because they provide very useful general background. These are the first two readings, "Land Remote Sensing: An Overview," and "Weather Satellites: An Overview."

Mr. Chairman, we commend this report to you and to other Members of the Committee.

Sincerely,

JAMES H. SCHEUER
Chairman, Subcommittee on
Natural Resources and
Environment

Harold L Volkmer
HAROLD L. VOLKMER
Chairman, Subcommittee on
Space Science & Applications

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LETTER OF SUBMITTAL

April 12, 1983

Honorable Harold Volkmer
Chairman, Subcommittee on Space Sciences
  and Applications
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Pursuant to your request, we are hereby submitting to you a report entitled U.S. Civil Remote Sensing Satellites: Commercialization Policy and Issues. Ms. Patricia Humphlett, Analyst in Aviation and Space Sciences of the Science Policy Research Division prepared the report and selected the readings appended thereto. The information in this report is current as of March 31, 1983.

We hope that this report will serve you and the members of your subcommittee in your continuing consideration of issues involved in transferring civil remote sensing satellite systems to the private sector.

Sincerely,

Gilbert Gude

Gilbert Gude
Director

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U.S. CIVIL REMOTE SENSING SATELLITES: COMMERCIALIZATION POLICY AND ISSUES

Prepared for the
House Science and Technology Committee
Subcommittee on Space Science and Applications

Patricia E. Humphlett
Analyst in Aviation and Space Sciences
Science Policy Research Division
April 11, 1983

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INTRODUCTION

On March 8, 1983, President Reagan announced his endorsement of the transfer of the civil land remote sensing system (Landsat), the civil weather satellite system, and future ocean observing systems to the private sector. His endorsement begins a process through which transfer proposals will be requested from the private sector to help determine the feasibility of transferring all or part of these systems to the private sector. This course of action is based in part on the theory that private enterprise is the driving force of the economy and that the Government should not compete with the private sector. Accordingly, the Government should, whenever possible, buy products and services from the private sector, especially when this leads to greater efficiency and cost savings.

The Federal Government has never intended to own and operate a commercial land remote sensing system. There has been little objection to the eventual transfer of Landsat to the private sector once its operational capability was proven and a commercial market was developed. The idea of transferring weather satellites is, however, relatively new and has generated some controversy. The initial congressional response to the President's announcement has been somewhat negative with concerns being raised that the Administration is moving too fast toward a transfer without congressional involvement and that the transfer may not be in the national interest. The Administration has attempted to allay congressional concerns by indicating that no systems would be sold unless all prerequisites for security, reliability, data continuity, and cost savings are met, and then only with congressional approval. CRS Issue Brief 83072, Commercialization of Landsat and the Weather Satellites, outlines congressional action on this issue.

U.S. CIVIL REMOTE SENSING SATELLITE SYSTEMS

LANDSAT

Landsat is a remote sensing satellite that returns spectral data in both visible and infrared wavelengths, which can then be processed into images and digital information. The first Landsat was launched by NASA in 1972. Landsat 4, the current operational satellite, was launched in July 1982. The final satellite planned in the series, Landsat D prime, has been built and is planned for a 1985 launch. Landsat 4 carries two sensors. The multispectral scanner (MSS) was one of two sensors carried on the three previous Landsats and is considered the operational sensor. It has an 80 meter resolution and returns data in 4 spectral wavelengths. The other sensor on Landsat 4 is the thematic mapper (TM) which is being flown for the first time and is still experimental. The TM is a more advanced sensor with a 30 meter resolution and returns data in 7 spectral wavelengths.

Operational responsibility for the MSS on Landsat 4 was transferred to the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce on January 31, 1983. The TM will remain under the National Aeronautics and Space Administration (NASA) until January 31, 1985, when it will be considered operational and will be transferred to NOAA.

Landsat data are used by the Departments of Agriculture and Interior, the Agency for International Development, NASA, private industry, universities and others in the Government and private sector. Foreign governments also purchase Landsat data and there are ten ground receiving stations worldwide that receive Landsat data directly.

Issue Brief 82066, Landsat (Earth Resources Satellite System), discusses Landsat in greater detail. (See also reference 1*)

CIVIL WEATHER SATELLITES

There are currently four operational satellites in the civil weather satellite system which are operated by NOAA. Two polar orbiting satellites, NOAA-6 and NOAA-7, are in relatively low, near-polar orbits and provide whole-Earth data for weather monitoring and prediction programs. These satellites collect global environmental data such as atmospheric density and humidity, sea surface temperatures, snow and ice coverage, and day and night cloud distributions using four sensors. Two geostationary satellites, GOES-E and GOES-W, are in higher, equatorial orbits providing repetitive Earth views for U.S. severe weather warning and other services. These geostationary weather satellites each carry three sensors which return data in infrared and visible wavelengths to provide cloud motion and wind information, precipitation estimates, frost monitoring, and other information. The two kinds of satellites are designed to provide complementary data. (Reference 2)

The Federal Government uses 95 percent of the data from the civil weather satellites. The National Weather Service, in NOAA, is the primary user, producing forecasts and other weather information from the satellite data. Weather satellite data have been available without charge to the public and to the media which provide weather watch and warning information as a public service. The Department of Defense is the other major user; data from NOAA's polar orbiting satellites frequently supplement the Defense Meteorological Satellite Program (DMSP). (Reference 3)

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*References refer to numbered readings contained in this report.

The United States also has international agreements for the free exchange of weather data in which the United States distributes satellite data in exchange for foreign ground-based data.

OCEAN SENSING SATELLITES

The United States launched an ocean sensing satellite, Seasat, in June 1978. The satellite operated for less than four months before an electrical malfunction caused it to fail in orbit. Plans for NOSS, an ocean remote sensing satellite sponsored jointly by the Department of Commerce, the Navy, and NASA, were cancelled due to budget constraints. The Navy has shown an interest in pursuing its own ocean satellite, called N-ROSS, but no budget request has been forthcoming, and discussions are continuing between the three agencies to determine what direction a Government program should take. Ocean sensing satellites were included in President Reagan's March 8, 1983 announcement for transfer of U.S. civil remote sensing satellites to the private sector.

BACKGROUND

Landsat was developed as an experimental satellite system with no definitive plan for converting it to either an operational or commercial system. Following years of debate in the Congress and the Administration, President Carter issued presidential directive 54 in 1979 which assigned the responsibility for an operational Landsat system to NOAA and also requested that NOAA consider private sector opportunities in civil land remote sensing activities with the goal of eventual transfer of Landsat to the private sector. The Carter Administration planned to build and launch Landsat 4 and three follow-on satellites which would have continued the Landsat program through 1994.

The Reagan Administration also supports the policy of transferring Landsat to the private sector and is proposing that weather and ocean sensing satellites be transferred as well. This policy is based on the view that the Government should not compete with the private sector. Office of Management and Budget (OMB) Circular A-76 contains the rationale for this policy, stating that the Government should not produce goods or services where the private sector can provide them more efficiently and cheaply.

The Reagan Administration also shortened the time frame during which the transfer might occur. Two of the Landsat follow-ons have been eliminated from the budget and only one more Landsat, Landsat D prime, will be launched in 1985. Since each Landsat spacecraft has a life expectancy of 3 years, Landsat data should be transmitted through 1988. A lead-time of approximately 4 years is required to build and launch a satellite, so a follow-on to Landsat D prime would have to be initiated in 1984 in order to ensure program continuity. With no plans for launches beyond 1985, the federally-operated Landsat program would end in 1988. If not picked up by the private sector by that time, this would end U.S. land remote sensing activities. (Reference 4)

CABINET COUNCIL ON COMMERCE AND TRADE

On July 13, 1981, President Reagan assigned the Cabinet Council on Commerce and Trade (CCCT), chaired by Secretary of Commerce Malcolm Baldrige, the responsibility for assessing (1) the best mechanism for transferring Landsat to the private sector as soon as possible, and (2) if the weather satellites should be transferred at the same time. The CCCT met to discuss these issues in December 1981, and March and April 1982. Proceedings and recommendations of the Council are for the internal use of the Administration and are not made public. However, according to one report 1/ , the Council decided at the April meeting that the weather satellites should remain under the control of the Federal Government and that further study was needed on alternate ways to commercialize Landsat.

LAND REMOTE SENSING SATELLITE ADVISORY COMMITTEE

The Secretary of Commerce established the Land Remote Sensing Satellite Advisory Committee (LRSSAC) in August 1981 to advise the Secretary on the issue of transferring Landsat to the private sector. The LRSSAC, chaired by Michel Halbouty, is a group of individuals from non-Federal communities interested in civil remote sensing. In June 1982, the LRSSAC, in considering the two questions before the CCCT, advised the Secretary to issue a Request for Information (RFI)

1/ Aviation Week and Space Technology, Apr. 26, 1982, p. 17.

to solicit industry opinion. (Reference 5) The RFI was issued in September 1982 and in November LRSSAC chairman Halbouty established the Working Group on Commercialization to evaluate the industry responses. The Working Group consicted of five members of the LRSSAC having no conflict of interest in the responses or their evaluation. The Working Group's report was endorsed by the full committee and released on November 19, 1982. (Reference 7) The report emphasized the need for continuity in U.S. civil remote sensing satellite systems and recommended that the Government negotiate with private industry for the transfer of ownership or operation of the space and ground segments of land and/or weather satellites up to and including the receiving of raw unprocessed data, but not including value-added processing. According to NOAA, this recommendation would effectively prohibit the transfer of the remote sensing systems to a single private firm. There is, however, some disagreement on this conclusion resulting from the question of whether data preprocessing is included in the receiving of raw data, or if preprocessing is excluded along with value-added processing.

REQUEST FOR INFORMATION

The Secretary of Commerce issued a request for information (RFI) on September 10, 1982,to solicit industry opinion. (Reference 5) Twelve responses were received from industry and two from universities. (Reference 6)

The Communications Satellite Corporation (COMSAT) was one of the respondents to the Department of Commerce RFI, and was the only one to recommend full commercialization of both land and weather satellites. COMSAT had first presented its plan for land and weather satellite commercialization to the Secretary of Commerce on December 14, 1981. COMSAT believes that by combining the operations of the two systems it can operate both more efficiently and at a lower cost than the two are operated by the Federal Government. COMSAT estimates it can save the Government around $1 billion over a decade. Landsat alone does not have a sufficiently strong user market at the present time for a viable commercial venture, and COMSAT has argued that the guaranteed market for the weather satellites would be necessary to make commercialization profitable.

COMSAT has not made a formal proposal for the purchase of the land and weather satellite systems, but has outlined possible terms. These terms include the purchase of the existing civil remote sensing satellites systems for $250-350 million and a 15 year contract with the Government for the purchase of data at about $300 million per year. COMSAT assumes that the Government will continue to purchase and disseminate land and weather data and estimates that the Federal Government would save $1 billion in operating costs over the next ten years.

Other respondents included such large private companies such as Hughes, RCA, General Electric and Control Data Corporation. Generally the responses advised continued Government retention of Landsat or a gradual commercialization over several years to allow the user market to develop. Some respondents expressed an interest in acquiring part of either the land or weather satellite systems. American Science and Technology, for example, expressed an interest in acquiring the command and control segment of Landsat, which they would later integrate into their own land satellite series which they plan to launch starting in 1985.

TECHNICAL AND BUSINESS EVALUATION COMMITTEES

Two Government interagency panels were formed by the Secretary of Commerce to carry out a technical and business evaluation of the responses to the RFI. The Technical Evaluation Committee (TEC) was chaired by Major General Earl Peck, Director of Intelligence and Space Policy at the Department of Defense; the Business Evaluation Committee (BEC) was chaired by Kathleen Charles, Deputy Comptroller at NASA's Goddard Space Flight Center. The panels submitted their reports to the Department of Commerce on November 10, 1982.

The TEC report reviewed the industry responses based on four criteria: responsiveness to federal needs, continuity of data services, technical feasibility, and national security and foreign policy concerns. Most of the industry responses did not specifically address these criteria, but discussed general issues involved in the transfer of Landsat and the weather satellites to the private sector. The TEC report strongly cautioned that a transfer which created a monopoly might harm Government interests and inhibit the free market process. The report also expressed concern that a non-Government monopoly might lack incentive to pursue the research and development necessary to preserve the U.S. technological lead in this field. The report expressed concern about private sector operation of weather satellites:

> It is also the belief of this panel that there is considerable financial, policy and program risk to the government in commercializing weather satellites and that there is no clear policy or financial benefit to be realized. Too, there is no clear consensus among the respondents as to the desirability or feasibility of commercializing any of our civil remote sensing systems at this time.

The TEC report also raised several national security concerns because of the potential use of data for military and intelligence purposes, and predicted that the problem would worsen as the satellites became more sophisticated. It also raised the issue of the need for control over data dissemination and emergency use of the services for defense applications. The report also observed, however, that a request for proposals (RFP) might answer some of these questions.

The BEC report concluded after reviewing the responses to the RFI that the user market for Landsat data is not presently large enough to support a private operation without a Government guarantee or subsidy. The report suggested that commercialization begin with the value-added segment of the system and gradually include data pre-processing, data receipt and archiving, and then the space segment of the system. According to the report, only two of the respondents, COMSAT and American Science and Technology, recommended the transfer of land and/or weather remote sensing systems to the private sector. Three large aerospace firms, General Electric Co., Hughes Aircraft Co., and RCA, did not support near-term commercialization.

COMSAT provided the most complete information in terms of how the transfer could be implemented and what such a transfer would cost. The panel's cost evaluation of COMSAT's estimates compared them to the Federal budget in which Landsat operations are discontinued after Landsat D prime so that Government purchase of any land remote sensing data is an added expense and not a savings. Based on these assumptions, the BEC found that COMSAT's plan would cost the Government an additional $798 million over the first 10 years of commercialization. COMSAT's estimate--$1 billion savings over 10 years--is based on a comparison of its program with the projected costs of the continued Government operation of the current Landsat and weather satellite programs. Neither COMSAT nor the BEC report considered the possible additional Government costs in COMSAT's plan through accelerated cost recovery and investment tax credits which could indirectly lead to Federal revenue losses.

PL 97-324 STUDIES

The FY83 NASA authorization act, PL 97-324, provides authority for NOAA to conduct the operational Landsat program and requires not less than three studies on the transfer of the civil remote sensing satellites. One study was to be completed by February 1, 1983 by the National Environmental Satellite, Information and Data Service (NESDIS) in NOAA. This study was to include Government land remote sensing data needs and an inventory of equipment, software, and data that could be transferred to the private sector. The study was also to compare possible transfer approaches including Government/private ownership and operation, a legislatively chartered privately owned corporation, and continued Federal ownership and operation. These alternatives were to be evaluated based on criteria such as data continuity, U.S. technological leadership, national security and costs to the Government and users.

Three similiar studies were contracted out to the National Academy of Public Administrators (NAPA), ECON, Inc., and Earth Satellite Corporation (EARTHSAT), to be completed by April 1, 1983. None of the studies requested in P.L. 97-324 were available as of March 31, 1983.

PRESIDENT REAGAN'S ANNOUNCEMENT

The Cabinet Council on Commerce and Trade met again on December 15, 1982 in closed session to reconsider the issue of commercialization in light of industry responses and the reports from the LRSSAC and the Technical and Business Evaluation Committees. In an apparent reversal of its previous position, the Cabinet Council recommended the transfer of civil land, weather and future ocean remote sensing satellites to the private sector. (Reference 8) The importance of relying on the strength of the private sector evidently won out over concerns in the Council about the commercialization of the weather satellites. The CCCT's recommendation was forwarded to President Reagan for approval. On March 8, 1983 Reagan announced his endorsement of the recommendation.

Secretary of Commerce Baldrige subsequently elaborated on the Administration's endorsement, stating that the announcement was intended to open public debate on whether the civil remote sensing satellite systems should be transferred to the private sector. 2/ Thus, President Reagan's announcement begins a process

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2/ Baldrige, Malcolm. Transfer May Save Money, Aid Efficiency. USA Today, Mar. 29, 1983. p. A8.

through which the private sector will submit proposals for taking over all or part of the systems, providing information to help determine the feasibility of such a transfer. Baldrige stated that the civil remote sensing systems could be transferred to the private sector with sufficient provisions to guarantee national security, data continuity, and cost savings; no sale will be made without meeting these requirements or without the approval of Congress.

ADMINISTRATION'S TENTATIVE TRANSFER SCHEDULE

The shortest legal time period during which a transfer could be implemented is one year. The complexity of the process, however, will probably draw the transfer out beyond that time period. The transfer will be carried out by a competitive process, conducted by the Department of Commerce, in which private firms will enter bids on the land or weather satellites as separate systems or a single bid for both systems. The transfer process begins with the formation of a source evaluation board. Three additional committees under that board will be formed for business and technical evaluations and for the drafting of legislation. The Department of Commerce will then begin to solicit industry input on the language for the formal request for proposals (RFP) which will include Government-required terms and conditions and Government data requirements. When the RFP is issued, it will include a 3 month turn-around time during which industry will be provided the information needed to make a proposal. Proposals will then be received for review and analysis. Legislation will be drafted, and (after receiving appropriate review in the executive branch) will be submitted to the Congress. With congressional approval of the legislation, the satellite systems could then be transferred to the private sector.

ISSUES

USER MARKETS FOR LANDSAT

The primary reason that Landsat has not been transferred to the private sector is that the system does not have a strong user market and, at present, data sales are not large enough to meet procurement and operations costs. Landsat has cost on average approximately $75-100 million a year to build and about $50 million a year to operate (based on 1983 assumptions). NOAA expects to recover $13.6 million in data sales to non-Federal users and $8.5 million from Government users in FY83. 3/ A commercial Landsat system at this time therefore would require substantial Government subsidization in order for a private firm to make a profit.

The lack of a user market is in large part the result of the uncertain status of Landsat as an experimental program under NASA. President Carter's directive in 1979 assigned responsibility for an operational Landsat program to NOAA and increased the emphasis on meeting user needs. Currently, the Federal Government is planning to launch one more satellite which would provide Landsat data through 1988. The uncertainty of data availability after 1988 has inhibited more extensive use of Landsat by many current and potential users. In order to justify large investments and long term projects, the user must be assured of long-range data availability.

The private sector has not established its own operational system because of the magnitude of investment in data interpretation equipment and personnel

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3/ U.S. General Accounting Office. Costs and Uses of Remote Sensing Satellites. Mar. 4, 1983.

training, the uncertainty of the commercial market, the non-aggregate status of the user community, and the lack of Federal support. An operational system could be cheaper to build and operate than an experimental system, such as Landsat. Data gathering systems could be tailored to the market rather than to research interests. This type of system would, however, ignore the non-commercial user and could inhibit the development of further uses of this technology. (Reference 9)

Under private ownership, land remote sensing data may need to be copyrighted in order to control its dissemination. The question then arises as to whether the U.S. Government would have to pay twice to purchase information both for its own use and for further dissemination.

TRANSFER OF WEATHER SATELLITES

The immediate combined transfer of Landsat and the weather satellites was first proposed by COMSAT, which recognized that the market for Landsat alone was insufficient to support a commercial operation. COMSAT determined that only with a guaranteed market for weather data could it afford to operate Landsat. A private weather satellite operator would be required to reach some agreement on how to continue to meet the needs of the U.S. Government and how to deal with foreign users. The Department of Defense is reported to have voiced the strongest objections to the transfer of weather satellites. According to one report, the Pentagon still is not "overly enthusiastic" about commercialization and will require broad constraints on any private operator. 4/ Critics have argued that selling the weather satellite system would decentralize the weather forecasting

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4/ Pentagon Accepts Weather Satellite Shift, Sets Navstar Fees. Aerospace Daily, Mar. 21, 1983. p. 115.

system and reduce NOAA's ability to predict severe storms. Others fear that the transfer might jeopardize national security or harm international relations. Some argue that the transfer might result in a monopoly that would lack incentive to pursue new technology.

OPEN SKIES VERSUS PRIOR CONSENT

The U.S. open skies policy has always been applied to the Landsat system, and a private sector operator will probably be required by the Government to continue this policy. Landsat returns data about the entire world, and under the open skies policy, the data are available to any purchaser on equal terms. A private Landsat operator would probably be required to continue this policy.

The U.S. open skies policy has been challenged in the United Nations because some countries feel that the data concern their natural resources and might affect their national security. These countries want the right of prior consent, meaning the right to see the data first and then to determine to whom the data is distributed. Civil land remote sensing satellites are not as sophisticated as military reconnaissance satellites, and Landsat data at present has little military value. As more countries launch remote sensing satellites and as the resolution of the instruments improve (the French SPOT satellite will have 10 meter resolution, three times more accurate than the thematic mapper on Landsat 4), the debate over access to data is likely to become more heated. Some concern has also been voiced that a private company operating a land remote sensing system might use a "first look" ability to its advantage, locating valuable resources before anyone else is aware of their existance. In the interest of enhancing U.S. foreign relations, a private Landsat operator may be required to follow some U.S. Government regulations.

INTERNATIONAL COMPETITION

The United States is currently the only country with a land remote sensing system providing data to users throughout the world. This status will soon change when France launches its remote sensing satellite, SPOT, in early 1985. SPOT Image, the marketing agent, is already working aggressively to develop the data market. SPOT will have some capabilities that Landsat does not have, including stereoscopic imaging and improved resolution--20 meter in color and 10 meter in black and white. SPOT will have only three spectral bands, compared to the thematic mapper on Landsat 4 which has seven. SPOT data will be complementary to Landsat data because of the differing capabilities. It is also possible that SPOT may capture some of Landsat's data market, particularly if there is a gap in Landsat data availability. International Landsat ground receiving stations could be modified to receive SPOT data. SPOT will also have an advantage because it is backed with strong government support which gives a greater assurance of data continuity. (References 10 and 11)

Japan plans to launch a satellite called ERS for oil and mineral exploration in the mid-1980s. The European Space Agency also plans to launch an ocean resources satellite. The Soviet Union collects remote sensing data from its manned space stations and its unmanned weather satellites. At present this data is distributed only among Soviet-bloc countries, but this policy could change.

INTERNATIONAL COOPERATION

The existing Landsat system has encouraged the use of data by international users who can either receive the data directly from the satellite at a foreign ground station or purchase the data from the United States. If the system were transferred to the private sector, the terms of the transfer would have to consider providing continued access for these international users. There are ten ground receiving stations for Landsat world wide and plans for the construction of two more stations; other countries have expressed an interest in building stations to receive Landsat data directly. In addition to paying for the construction of the facilities, the countries pay an annual access fee of $600,000 for each ground station. These countries are also required to make data available on equal terms in accordance with U.S. policy. Foreign users have invested in facilities and training and therefore are concerned that the program might be disrupted or changed in the future as the result of a transfer to the private sector.

Landsat has been a foreign policy tool for the U.S. Government. The U.S. Government has met with representatives from France, Japan, and other countries to discuss the development of their remote sensing systems in an effort to produce compatable capabilities in data receiving and processing equipment. This kind of international cooperation has helped promote the value of remote sensing and the role of the U.S. in this field. The Agency for International Development in the Department of State has also provided Landsat data to developing countries for use in resource planning and management.

Data from U.S. civil weather satellites are received directly by over 800 ground stations located in over 120 countries worldwide. Data from U.S. civil weather satellites have been provided without charge to foreign countries in exchange for data from their ground-based stations used in both civil and military forecasts. France and the United Kingdom provide instruments for the U.S. polar orbiting satellites without charge. The U.S. will likely continue to want this kind of international cooperation which will require close cooperation between the Federal Government and a private operator.

NATIONAL SECURITY

The Federal Government has established limits on the sensing parameters of remote sensing satellites to ensure that they do not disclose sensitive military information. President Carter's presidential directive 37 contains restrictions on civil satellite capabilities, but the report and the restrictions are themselves classified. Since NASA has developed a Large Format Camera with 10 meter resolution, it can be assumed that this degree of resolution is acceptable. The French satellite SPOT plans to have an improved resolution of 10 meters. A private firm operating Landsat and its successors would need to have competitive sensor resolution capabilities, but would also have to remain within Federal restrictions.

The civil weather satellite system is separate from, but closely related to the Department of Defense's weather satellite system. The civil weather satellites often serve as a back-up to the Defense Meteorological Program (DMSP) which, according to some reports, has not been fully functioning in recent months. The civil and military weather systems frequently exchange data and this relationship requires flexibility and responsiveness. The systems use the same satellite design and have an interlocked shared data processing system which helps reduce costs. In order to continue this cooperation, the Government will need to continue to have input on criteria such as satellite replacement, orbital parameters, and instrument complement in the civil weather satellite system. A commercial operator of the civil weather satellite systems would be required to give priority service to the Department of Defense or even to transfer the civil weather satellites to DOD during a national emergency. A private operator would also be required to deny data access to hostile powers in times of crisis.

ROLE OF FEDERAL GOVERNMENT AFTER COMMERCIALIZATION

The Federal Government currently represents 25 percent of the data market for Landsat and 95 percent of the data market for the weather satellites and thus has a vested interest in the end products. The private sector appears unwilling to fund advanced, high risk satellite research and development. The Government may, therefore, be required to continue high risk research and development in this field in order to keep the U.S. competitive with other countries, much as it now does in advanced communications satellite research and development. France, in particular, will be pursuing the development of its own systems with government support. As a major user, the U.S. Government may also want to continue to influence satellite technology on a privately owned satellite.

The Federal Government must also be prepared for the possible failure of commercialization and to buy back into the systems in the event of a private sector failure. Presumably, terms for reverting any system back to Federal control would be part of a transfer agreement.

COMPETITIVE PROCESS

The transfer which President Reagan announced on March 8, 1983,calls for a competitive selection process. At this point, only COMSAT has prepared a detailed plan for commercialization and it is unclear whether enough other private firms will be interested to ensure a competitive process. In addition, if the satellite systems are transferred to the private sector with a guaranteed data contract, this might effectively prevent another firm from entering the remote sensing satellite market and competition would be precluded.

CONGRESSIONAL ROLE

The Department of Commerce has stated that it fully intends to implement the transfer of Landsat and the weather satellites with legislation passed through Congress. There has been concern, however, that the Administration has in effect already made its decision and that Congress will not have sufficient voice in the many issues involved in the commercialization process. Legislation has been introduced to require congressional approval before any transfer takes place, since it unclear whether the Administration could implement the transfer without legislation.

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LAND REMOTE SENSING: AN OVERVIEW

Prepared by

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Congressional Research Service

(25)

LAND REMOTE SENSING: AN OVERVIEW

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LAND REMOTE SENSING: AN OVERVIEW*

I. Introduction

Early in the U.S. manned space flight program, astronauts using hand-held cameras photographed the Earth from the windows of their spacecraft. These broad synoptic views provided a new way to examine the Earth and were received with a high degree of interest. Concurrently, new types of high altitude imagery using multispectral scanners (MSS) were developed and tested using aircraft. These two activities resulted in a concept of a new global data acquisition system consisting of an MSS mounted on a satellite observation platform, a concept that ultimately become known as Landsat.

Landsat 1 was launched on July 23, 1972, followed by Landsat 2 on January 22, 1975 and Landsat 3 on March 5, 1978. Landsat 1 was retired from service on January 16, 1978 after exceeding its design life by four and a half years. Landsats 2 and 3 continue to return data at the end of 1981, but both have encountered problems. Landsat D, the next in the series, is scheduled for launch in July 1982 and will carry a new instrument, called a Thematic Mapper (TM), in addition to a four-band MSS. The TM will have a better ability to resolve images, and a much higher data rate. A backup spacecraft, called Landsat D' (D prime), will be launched in 1985 unless problems develop with Landsat D (the two spacecraft are identical). No further spacecraft are planned at the present time, although NASA is developing remote sensing experiments which will fly on the space shuttle.

The Landsat program continues to face problems in both the domestic and international spheres. The primary domestic question concerns what will happen to the Landsat program after D' is launched, in terms of how to move the system from experimental to operational status (especially whether it should be operated whether it should be operated by the government or private sector). Internationally, issues concerning who owns the data returned from remote sensing satellites (the country who operates the satellite or the country that has been sensed) and whether remote sensing satellites should be managed by an international body such as the United Nations, remain unresolved after more than a decade of debate.

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* Prepared by Marcia S. Smith, Specialist in Aerospace and Telecommunications Systems. Some of the material is updated from a chapter prepared by Lani Raleigh, formerly a Specialist in Aerospace and Energy Systems for "World-Wide Space Activities; which was published by the House Science and Technology Committee in 1977. Information in this report is current as of Dec. 31, 1981.

II. THE LANDSAT PROGRAM

A. The Spacecraft

Landsat spacecraft orbit the Earth at an altitude of 917 kilometers (570 miles) approximately once every 103 minutes, or 14 times a day. On each orbit, the satellite views a different 185 kilometer (115 mile) strip of the Earth running north/south from pole to pole. After 18 days, the satellite has viewed every place on Earth at least once. If two Landsats are in operation, the cycle repeats itself every 9 days.

Since uniform lighting is important for consistent data interpretation, sun-synchronous, near-polar orbits were chosen. The satellites therefore cross the equator at the same time each day, viewing any given area at approximately 09:42 a.m. local time.

Table 1 summarizes the characteristics of Landsats 1-3 and Landsat D (Landsat D' is the same as Landsat D).

B. Landsat 1-3

The Landsat spacecraft are patterned after the Nimbus meteorological satellites. The satellites weigh 953 kilograms (2,100 pounds) and have an approximate overall height of 3.04 meters (10 feet) and a diameter of 1.52 meters (5 feet), with solar panels extending out to a total of 3.96 meters (13 feet). 1/ Spacecraft attitude is controlled with a pointing accuracy of less than 0.7 degrees in all three axes (roll, pitch, and yaw). Two wideband video tape recorders store up to 30 minutes each of picture information for readout when the spacecraft is in view of a data acquistion station on the ground.

Landsat satellites carry a return beam vidicon (RBV) subsystem, multispectral scanners (MSS), and a data collection subsystem (DCS). The RBV and MSS provide independent images of the same 185 by 185 kilometer (115 by 115 mile) area of Earth in various spectral bands. The DCS collects and relays data from remotely located ground platforms to the Landsat data acquisition stations.

1. Return Beam Vidicom Subsystem. RBV cameras are used to view the same ground scene as the MSS, but are sensitive to different spectral bands. On Landsat 1 and 2, three RBVs were used to scan in the following spectral bands: 0.475 to 0.575 microns; 0.580 to 0.680 microns; and 0.690 to 0.830 microns. Landsat 3 carries two RBV scanners, both in the band 0.505 to 0.750 microns.

1/ Technical information was provided by NASA.

TABLE 1

LANDSAT SPACECRAFT CHARACTERISTICS

	LANDSAT 1	LANDSAT 2	LANDSAT 3	LANDSAT D
Launch Date	July 23, 1972	Jan. 22, 1975	Mar. 5, 1978	July 1982?
Design Life	1 year	1 year	1 year	3 years
Orbit				
Altitude	917 kilometers	917 kilometers	917 kilometers	705 kilometers
Equatorial Crossing	9:30 a.m.	9:30 a.m.	9:30 a.m.	9:30 a.m.
Repetitive Coverage	18 day	18 day	18 day	16 day
Instruments				
RBV	X	X	X	
MSS				
Resolution	80 meter	80 meter	80 meter (Bands 1-4) 240 meter (Band 5)	80 meter
Bands	4	4	5	4
Data Rate	15 Mbps	15 Mbps	15 Mbps	15 Mbps
Scenes/Day	170	200	200	200
TM				
Resolution				30 meter
Bands				7
Data Rate				85 Mbps
Scenes/Day				100
Data				
On-Board Storage	X	X	X	
Downlink	Domestic Readout	Domestic Readout	Domestic Readout	TDRSS and directly to ground
Foreign Stations Operating At Launch	0	3	5	10-12
Status As Of December 31, 1981	Operations Terminated	Operating; Tape Recorders Inoperative	Operating Partially; 1 Tape Recorder Inoperative; Band 5 Inoperative	Scheduled for July 1982 launch

Source: NASA

When the cameras are shuttered, images are stored on photosensitive surfaces within each vidicon camera tube; the tubes are then scanned to produce video outputs. The cameras scan in sequence, requiring about 3.5 seconds to read out each of the three images. To produce overlapping images of the ground along the direction of spacecraft motion, the cameras are reshuttered every 25 seconds. Full color images can be produced when each of the separate images is processed and superimposed in its respective color on a single frame. The resolution of the RBVs for Landsat 1 and 2 is 70-80 meters, while for Landsat 3 it is 26-40 meters, depending on exposure time. On Landsat 3, RBV scenes are only one-quarter the size of an MSS scene, so four subscenes are needed to provide the same coverage as the MSS.

2. Multispectral Scanners. Different materials on the Earth's surface absorb and reflect sunlight differently. For example, the wavelength at which the Sun's energy is absorbed by a plant for growth is dependent upon the plant type, plant maturity, and overall condition. It is therefore possible to determine the identity and condition of plants by the unique way in which they reflect energy from the Sun. The MSS measures this reflected energy, which is then sent to Earth in the form of digital data.

On Landsat 1 and 2, the MSS could scan in four different wavelengths: 0.5 - 0.6 microns; 0.6-0.7 microns; 0.7 - 0.8 microns; and 0.8 - 1.1 microns. A fifth band for measuring thermal (infrared) radiation was added to Landsat 3 at 10.4 - 12.6 microns, but this channel did not work properly.

Scanning is achieved by means of a mechanically oscillating mirror that flips from side to side about 13 times a second as the spacecraft progresses around Earth in its orbital path.

MSS image resolution is 80 meters for the first four bands, and 240 meters for the fifth band on Landsat 3.

3. Data Collection System. The data collection subsystem (DCS) aboard Landsat collects and relays data from up to 1,000 sensor-platforms located in remote areas throughout the United States to the Landsat data acqisition stations. Data are transmitted twice a day from each platform when the spacecraft is in simultaneous view of the transmitting platform and a data acquisition station. Each DCS platform collects data from as many as eight sensors, sampling such local environmental conditions as temperature, stream flow, snow depth, or soil moisture. Data from all platforms are relayed to the Goddard Space Flight Center in Greenbelt, Maryland and can be available to investigators within 24 hours after collection.

4. Spacecraft Status. Landsat 1, launched on July 23, 1972, outlived its design life by four and a half years and was finally retired on January 16, 1978. 2/ Its tape recorders had long since ceased functioning

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2/ Landsat 1 Earth Resources Satellite is Retired. NASA Press Release 78-9. January 23, 1978.

(the first in August 1972, the second in July 1974), and control problems had developed with the mechanism that kept the satellite pointed toward Earth (the pitch wheel). The satellite provided more than 300,000 pictures of the Earth.

Landsat 2 was launched on January 22, 1975 and at the end of 1981 was still returning data, although both of its tape recorders have failed (the first on January 26, 1977 and the second on May 21, 1981), meaning that data can only be acquired while the spacecraft is in view of a ground receiving station. Landsat 2 also experienced control problems (a rotating fly wheel became jammed due to degraded lubrication) that led to its being retired from service on the fifth anniversary of its launch on January 22, 1980. 3/ Engineers were able to devise an alternative method for stabilizing the satellite, using a magnetic compensation system, and it was returned to operational status in July 1980. During experiments with the magnetic system, the flywheel which had been stuck began operating again, but the magnetic system was still required to maintain the roll and yaw axes in a safe range. The control problems reappeared at the end of 1981, and the future of the satellite was gloomy as the year drew to a close.

Landsat 3 was launched on March 5, 1978 and was still returning partial data at the end of 1981 (one of the tape recorders failed on June 5, 1979). Problems developed in the MSS shortly after launch. The fifth band added to the MSS (the thermal band) worked for only a short time because of a design flaw in the cooling unit required for that band. The band had two detector channels -- one for scanning across the flight path of the spacecraft and one for scanning along it; the one which was designed to scan along the flight path failed. As a result, every other line in any image was missing. Only a limited amount of data was collected with the sensor for experimental purposes.

In the fall of 1978, another MSS problem developed with the way in which the scan lines are broken down for the other four bands. The problem was circumvented by switching to a backup system, but that developed the same problem in May 1979. The scanner builds up an image from swings of the oscillating mirror (described earlier). The data bits would form one continuous line if they were not then broken down and printed under each other to form a rectangular picture. Start and end pulses are used to tell the scanner where to break the line. The line scan monitor is not inserting the start pulses correctly, and some of the lines are offset by about 25 percent (a backup system inserts a start signal 25 per cent of the way across the line, thus saving the other 75 percent). Some of the pictures are not affected at all, some have 5 percent of the lines offset, and some have as much as 40 percent of the lines offset. Images taken between the 35° north and south latitude are affected the most.

3/ Landsat-2 Ceases Operation. NASA Press Release 80-9. January 22, 1980.

C. LANDSAT D and D'

Landsat D, the next in the series, is scheduled for launch in July 1982. An identical backup satellite, designated D' (D prime), is scheduled for launch in 1985 unless Landsat D fails prematurely.

These satellites will carry an MSS as well as an improved scanner called the Thematic Mapper (TM). 4/ The TM can sense data in seven spectral bands: Band 1 — 0.76 to 0.9 microns; Band 2 — 0.63 to 0.69 microns; Band 3 — 0.52 to 0.6 microns; Band 4 — 0.45 to 0.52 micron; Band 5 — 1.55 to 1.75 microns; and Band 6 — 10.4 to 12.5 microns, and Band 7 -- 2.08 to 2.35 microns. An aircraft-mounted TM simulator has been used to test the effectiveness of the band and resolution selections for this instrument.

Landsat D will be placed in a lower orbit than its predecessors: 700 kilometers instead of 917 kilometers. Coupled with the advanced instrumentation of the TM, image resolution will be 30 meters, or about one-fifth of an acre (compared to 80 meter, or 1.2 acre resolution with the MSS) for the bands 1-5 and 7; the sixth band has a resolution of 120 meters. (Bands 1-5 and 7 contain 16 detectors, while Band 6, for thermal radiation, has only 4). In addition, the data rate of the TM will be 110 megabits per second (mbps), versus 15 mbps on the MSS. NASA expects the TM to provide ten times the data of the MSS. The MSS is being included on the satellites to provide continuity to users of the data, and since the TM carries the thermal band, it has only the four bands used on Landsats 1 and 2.

Landsat D and D' do not carry tape recorders like the earlier satellites, because they can continuously relay data directly to ground stations or through the Tracking and Data Relay Satellite (TDRSS) to the ground.

The issue of whether or not to include an MSS on Landsat D and D' was a matter of dispute during consideration of NASA's FY78 budget request. The Office of Management and Budget (OMB) felt that sufficient experience had been gained with the MSS instrument so that no further research and development flights were required and rejected NASA's request for funding to include an MSS. NASA and the user community wanted the MSS on board to provide for a transition period between using MSS and TM data, but NASA was unable to get money from the user community to pay for it. 5/

4/ The name "thematic mapper" was chosen to describe the way in which the data will be used to more narrowly categorize crops, geologic formations, etc., into groups or "themes." The instrument itself is simply an uprated multispectral scanner.

5/ NASA Plans No Multispectral Scanner for LANDSAT-D, Weighs Need. Aerospace Daily, February 3, 1977, p. 174-5.

In acting on the budget request, Congress authorized NASA to allocate $2 million of its FY78 funding to provide an MSS on the spacecraft. 6/ A committee was formed by the President's Science Adviser, Frank Press, to assess the need for the MSS, and it concluded that the instrument should be carried. 7/ With Congress and the Administration supporting inclusion of the MSS, the instrument was approved.

Ironically, difficulties encountered in developing the TM during 1979 and 1980 almost forced NASA to drop the TM from the spacecraft and fly only the MSS. The original launch date for Landsat D was to have been September 1981, a date which NASA felt had to be kept in order to assure continuity of data flow to users, as well as to allow for an orderly transition of the system from experimental to operational status. In October 1979, NASA's Associate Administrator for Space and Terrestrial Applications, Anthony Calio, reported to the House Science and Technology Committee that he was "not optimistic" that the prime contractor for the TM (Hughes Aircraft) would be able to meet the September 1981 deadline for delivery of the first TM, and alerted the committee to the possibility that the launch date might slip. The problem was attributed to poor management by the prime contractor. 8/ The cost of the TM, originally estimated at $38 million, rose to $85-90 million during this period (for two flight models).

In April 1980, NASA announced that it was studying various options for restructuring the Landsat D program because of increasing engineering and managerial problems encountered in the manufacture of the spacecraft's instrument and ground systems. The three options considered by the agency were to: launch Landsat D with both the TM and MSS as soon as possible; launch Landsat D as soon as possible with only the MSS, to be followed as soon as possible by Landsat D' with both instruments; and to launch Landsat D and D' only with MSS instruments. 9/

6/ U.S. Congress. Committee of Conference. National Aeronautics and Space Administration Authorization, Fiscal Year 1978. 95th Congress, 1st session. House Report 95-448. Washington, U.S. Govt. Print. Off., June 21, 1977. p. 8.

7/ Multispectral Scanner Urged for Landsat D. Aviation Week and Space Technology, December 5, 1977, p. 49.

8/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. 1981 NASA Authorization (Program Review). 96th Congress, 1st session. October 16, 17, 18, 1979. Washington, U.S. Govt. Print. Off., 1979. p. 16.

9/ NASA Considers Options for Restructuring Landsat-D Program. NASA News Release 80-46, April 14, 1980. 3 pp.

In September 1980, NASA reported to Congress that the launch date for Landsat D would be slipped to the second half of 1982, while asserting that the TM would not be allowed to pace the program. With or without that instrument, the spacecraft would be launched. NASA added that the outlook for the TM was getting brighter. 10/

The TM for Landsat D was delivered to NASA on September 30, 1981 (the second is expected to be delivered in October 1982). The final cost for the two TMs is $120 million. 11/

Initially, NASA will acquire only one scene per day from the TM because the processing system for the data will not be completely ready until mid-1983. After that time, 12 scenes per day will be obtained for an additional experimental period, with 100 scenes per day expected to be acquired once the TM is operational in 1985. In addition, since the Tracking and Data Relay Satellite System will not be in orbit until early 1983, intital TM data will only cover the eastern part of the United States where it can be relayed directly to Goddard Space Flight Center (other Landsat receiving stations do not yet have the capability to receive the high TM data rates).

D. Program Costs

Through the end of FY81, NASA had spent $827 million on the Landsat program. FY82 NASA funding was expected to be $83.9 million, while the National Oceanic and Atmospheric Administration (NOAA) which will take over operation of the Landsat system in January 1983 (see below), was expected to spend $1.1 million on Landsat in FY82.

Table 2 provides a breakdown of NASA funding for the Landsat program.

10/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. 1982 NASA Authorization (Program Review). 96th Congress, 2nd session. September 16, 17, 18, 1980. Washington, U.S. Govt. Print. Off., 1981. p. 310.

11/ NASA Office of Congressional Affairs, June 1982.

TABLE 2

NASA FUNDING FOR THE LANDSAT PROGRAM
(in $ millions)

	Through FY81	FY82 Estimate	FY83 Request
DEVELOPMENT			
Landsat 1 & 2	$187.3*	--	--
Landsat 3	$ 43.8	--	--
Landsat D & D'	$344.6	$ 83.9	$ 61.7
OPERATIONS			
Landsat 1	*	*	*
Landsat 2 & 3	$ 2.0	$ 2.6	$ 1.7
Landsat D & D'	**	**	**

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* Figures for development and operations for Landsat 1 were not maintained separately by NASA.

** Landsat D and D' operations will be funded by the National Oceanic and Atmospheric Administration

Source: NASA Office of Legislative Affairs, June 1982.

III. USING LANDSAT DATA

A. Advantages of Remote Sensing Data from Satellites

The accuracy of data acquired from remote sensing satellites is for the most part dependent upon good supporting surface measurements (ground truth). Satellite information generally cannot stand alone without good ground truth data. Thus, satellite data is valuable not for replacing in-situ measurements, but for generalizing these measurements to areas so vast (country or regional scale) that conventional techniques cannot provide the integrating information at less than exorbitant costs. In general terms, satellite imagery has a 20:1 cost advantage over other methods of obtaining such data. 12/ Also, each Landsat picture covers 34,000 square kilometers or an area 185 by 185 kilometers. Thus, less than 600 Landsat images are required to cover the United States, compared to 500,000 photographs from high altitude aircraft.

The interpretation of satellite data is also less time-consuming than the interpretation of data derived from traditional survey techniques. This increase in the speed of data interpretation and repetitive coverage enables the user to effectively monitor such constantly changing phenomena as crop growth. As one of its earliest applications, investigators employed Landsat 1 data to furnish information needed to curb the cotton bollworm in a 320,000 hectare (800,000 acre) cotton field in California's Imperial Valley. The most effective method of curbing this pest is by the timely uprooting of cotton plants. This requires tight scheduling: the cotton must be harvested as soon as it has matured, and then the plants must be promptly plowed under. To accomplish this, farmers must closely monitor the status of crop growth. Landsat 1 investigators provided a complete inventory of crop status in 16 person-hours, compared to 128 person-hours that would have been required using traditional methods. 13/

B. Users of Landsat Data

Landsat data are used by Federal, State and local governments, as well as by the private sector and foreign countries. In the nearly ten years

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12/ James Welch, NASA Office of Space Science and Applications, private communication, June 1982.

13/ Lani H. Raleigh. Specific International Applications Satellite Programs. In: World-Wide Space Activities. Committee Print. Prepared for the House Committee on Science and Technology by the Science Policy Research Division of the Congressional Research Service. Washington, U.S. Govt. Print. Off., 1977. p. 439.

that Landsat data have been available, a wide variety of applications have developed. Specific examples have been presented in many other publications and need not be repeated here. 14/

In general, Landsat data has been used for applications such as agriculture (particularly crop forecasting), forestry, fishing, mineral exploration, land and water resource management, hydrology, geology and mapping, pollution monitoring, and coastal zone management.

NASA established three Regional Application Centers (RACs) in 1978 to assist State and local governments in utilizing satellite remote sensing data. The RACs are located at three NASA field centers: Goddard Space Flight Center in Maryland, the National Space Technology Laboratories in Mississippi, and Ames Research Center in California. By May 1981, 26 States had developed operational capabilities for using Landsat data. 15/ These activities are funded through NASA's technology transfer program. NASA, through its International Affairs Division, and the Agency for International Development have sponsored programs to assist foreign countries in utilizing Landsat data (discussed in section V).

In early 1982, Metrics, Inc. of Atlanta, Georgia released a worldwide market study for satellite remote sensing services which estimated that hardware procurement would rise from the current annual level of $45 million to $150 million by 1990, and data services would rise from $38 million to more than $150 million annually. 16/

One method of assessing the use of Landsat data is to look at the amount of data puchased by various classes of users. Table 3 provides a customer profile by dollar value of Landsat data purchases; data was taken from the EROS Data Center's Landsat Data Users Notes for January 1982.

C. Availability and Cost of Landsat Data

U.S. policy regarding access to data from the Landsat program is that it is available to everyone. This is termed the "open skies" policy and is not accepted as a world-wide standard. The international debate over this issue is reviewed in Section E.

14/ For example, see: Raleigh, ibid., pp. 440 ff; Barry S. Siegal and Alan R. Gillespie, eds. Remote Sensing in Geology. New York, John Wiley & Sons, 1980; William L. Smith, ed. Remote-Sensing Applications for Mineral Exploration. Stroudsburg, Pa., Dowden, Hutchinson & Ross, Inc., 1977.

15/ Paul A. Tessar, Loyola M. Caron, and Jane Germano. A Survey of State Applications of, and Investments in, Landsat Technology. Denver, National Conference on State Legislatures, May 1, 1981. p. vii/

16/ Aviation Week and Space Technology, February 8, 1982, p.. 13.

TABLE 3

USERS OF LANDSAT DATA: FY 1977-1981

	FY77	FY78	FY79	FY80	FY81
Dollar Volume of Total Landsat Sales	$1,453,837	$1,976,068	$2,131,813	$2,388,567	$2,495,268
Category of User					
Federal Government	26%	31%	23%	16%	19%
State/Local Government	1%	1%	1%	3%	4%
Academic	10%	8%	11%	9%	8%
Industrial	28%	24%	24%	26%	31%
Individual	5%	4%	5%	4%	5%
Non-U.S.	30%	32%	36%	42%	33%

Source: EROS Data Center. Landsat Data Users Notes, January 1982, p. 12.

In the United States, Landsat data are processed initially at NASA's Goddard Space Flight Center. Master copies of all data are sent to the Earth Resources Observation System (EROS) Data Center, which is operated by the Department of Interior at Sioux Falls, South Dakota (NOAA will take over some of these activities when it accepts responsibility for the Landsat program in January 1983 — see Section IV). These data are stored, reproduced, and disseminated to the general public on demand for a fee. The United States, through NASA, the Departments of State and Interior, have cooperative programs with over 50 countries for utilizing Landsat data. There are also a number of foreign Landsat ground stations which acquire their own data from the spacecraft (see Section V).

A major problem encountered with the availability of data has been the amount of time required for a user to get it. At one time, there was a backlog of as many as six months for obtaining the data, although by the end of 1981, this had been reduced to a two-week wait. With Landsat D and its interface with the Tracking and Data Relay Satellite, NOAA expects to provide data within 48 hours.

The cost of the data has increased over the years. Initially, the price reflected only the direct costs associated with processing, reproduction, and distribution of the data products. In January 1977, however, new prices were established to reflect overhead costs (such as packaging and mailing) as well.

In December 1981, NOAA announced that prices for Landsat products and services would increase again as of October 1, 1982. Prices will go up about two and one-half times their previous level. NOAA explained the cost increase as resulting from the decision that "users bear the costs of operating and maintaining the operational NOAA Landsat-D system through the fees they pay for the products and services provided by the system." 17/

Data are available in several different forms — film positives, film negatives, paper, microfilm, slides, and computer compatible tapes — and prices will range from $4.00 for a 35mm slide from the existing collection of images, to $1,300.00 for a computer compatible tape of 4 subscenes from the RBVs.

D. U.S. Government Programs for Demonstrating Utility of Landsat Data

As outlined previously, Landsat data are used by Federal, State and local governments, as well as by the private sector and foreign countries. Two programs have been sponsored by the Federal Government to demonstrate

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17/ Information Update for Users of NOAA/NESS Satellite Data. NOAA Press Release, December 1981.

the utility of Landsat data for agricultural appplications; a third, for geological applications, was planned but has been subsequently cancelled.

As discussed elsewhere in this chapter, the future of the Landsat program is uncertain at this time because of questions concerning transfer of the operational Landsat from the Government to the private sector. Another component of the debate concerns the future of these Government-sponsored programs to demonstrate the utility of Landsat data. The tri-agency LACIE program was successfuly concluded during the 1970's, but its follow-on effort, AgRISTARS,* is now in jeopardy because of budget constraints. The GAP program for geological applications has been cancelled for the same reason.

1. Large Area Crop Inventory Experiment (LACIE). Remote sensing for agricultural purposes began in the 1960s using photographs from aircraft. This later developed into multispectral imagery from aircraft, and eventually, multispectral imagery from satellites.

Investigators using Landsat 1 images of California's Imperial Valley in 1972-73 inventoried more than 25 separate crops in 8,865 fields (458,800 acres) in 40 person-hours. Among the crops readily identified were corn, popcorn, soybeans, sorghum, oats, grasses, lettuce, mustard, tomatoes, carrots, onions, and alfalfa. Scientists could distinguish between wet-planted fields, plowed lands, harvested fields, and bare soil in areas as small as 10 acres. 18/

This experiment demonstrated the potential of satellite systems for making accurate, extensive, and repeated crop surveys and led to a larger experiment known as the Large Area Crop Inventory Experiment (LACIE). The LACIE program ran from 1974 to 1978 and was jointly sponsored by NASA, the Department of Agriculture (USDA), and the National Oceanic and Atmospheric Administration (NOAA). Total program costs were $50.3 million ($37.7 million from NASA, $9.6 million from USDA, and $3 million from NOAA).

The LACIE program was designed to demonstrate the capability of using remote sensing techniques and data processing systems in combination with more conventional techniques to improve the speed and accuracy of

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18/ Stanley C. Freden, Enrico P. Mercanti, and Donald E. Witten, eds. Symposium on Significant Results Obtained from Earth Resources Technology Satellite - 1. Volume II: Summary of Results. Greenbelt, Md., NASA Goddard Space Flight Center, May 1973. X-650-73-127. p. 74.

global crop forecasts. Wheat was selected as the sample crop because it is the most important internationally traded crop, is grown in a wide variety of regions throughout the world with differing climates, and is fairly well understood in terms of its spectral characteristics. 19/

The three major goals of the LACIE program were: (1) to achieve an accuracy such that at-harvest estimates be within 10 percent of the true estimate at the national level 90 percent of the time (this became known as the 90/90 criterion); (2) to establish the feasibility of acquiring and analyzing Landsat data within a 15 day interval; and (3) to determine how early in the crop year accurate estimates could be produced. 20/

The program was conducted in three phases. Phase I, from 1974-5, involved testing the system over the U.S. Great Plains where ground truth data could be easily provided to verify the accuracy of LACIE predictions. In Phase II, from 1975-76, the test area was expanded to cover Canada and two regions in the Soviet Union, as well as the Great Plains. In Phase III, from 1976-77, the area was broadened again to include all of the wheat growing regions of the Soviet Union, Australia, China, India, Brazil, and Argentina. 21/

LACIE results were mixed, improving as the program progressed. For Phase I, although LACIE provided estimates for winter wheat that were within 5 percent of the USDA estimate, the production estimate for spring wheat was about 25 percent lower than USDA's. The problem with estimating spring wheat production rested with technical difficulties in distinguishing between newly planted wheat and other spring grains. Thus LACIE underestimated the spring wheat acreage. Nevertheless, the combined accuracy for spring and winter wheat estimated fell within the desired accuracy for the program. 22/

19/ U.S Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. 1978 NASA Authorization. Hearings, 95th Congress, 1st session. February 2,4,5,6,7,9, 1977. Washington, U.S. Govt. Print. Off., 1977. p. 404.

20/ R. Bryan Erb. An Overview of the Large Area Crop Inventory Experiment and the Outlook for a Satellite Crop Inventory. Presented to the First Brazilian Remote Sensing Symposium, Sao Jose dos Campos, Brazil, November 27-29, 1978. Houston, Texas, NASA Johnson Space Center, March 1979. JSC-13761.

21/ Ibid.

22/ U.S. General Accounting Office. Crop Forecasting by Satellite: Progress and Problems; report to the Congress by the Comptroller General. Washington, U.S. GAO, April 7, 1978, PSAD-78-52. p. 7.

In Phase II, according to NASA, LACIE estimates "marginally missed" the 90/90 criterion for the Great Plains, met the 90/90 criterion for the Soviet Union, and missed it for Canada because the spring wheat acreage was underestimated. 23/ Regarding the NASA estimates of accuracy for the Soviet Union, the General Accounting Office (GAO) noted that LACIE projections overestimated acreage by about 12 percent and underestimated production by about 15 percent for winter and spring wheat combined, so the 90/90 accuracy was achieved only because of offsetting errors in the LACIE area and yield estimates. 24/

In Phase III, coverage of the LACIE program was reduced to detailed study of the United States and Soviet Union, with only a small amount of effort devoted to the other countries that were supposed to be part of the study. This reduction in scope was taken so that more time could be devoted to resolving technical problems in meeting LACIE's goals, especially in distinguishing between spring wheat and other grains.

Some of the problems encountered during Phase II were remedied by the time Phase III took place, and overall the results were good. A NASA press release noted that LACIE predicted a production of 91.4 million metric tons for the Soviet Union, compared with the official production estimates of 92 million metric tons, less than a one percent difference. The agency cautioned that "the capability to achieve such accuracy from year to year has yet to be demonstrated," however. 25/

NASA and GAO noted that the improved sensors on Landsat D would provide increased sensitivity and higher resolution which could aid in distinguishing between spring wheat and other grains. 26/

Dr. Don Paarlberg, former Director of Economics for USDA, chaired a peer evaluation team to review the LACIE techniques. The report concluded that LACIE results "clearly demonstrate that present remote-sensing capabilities can be combined with or substituted for conventional methods of information collection in order to improve foreign crop production estimates." The report added that in some areas, such as the Soviet Union, LACIE technology was ready to be made operational, while "for regions where the technology requires improvement, funding for further research and development should be continued." 27/

23/ 1978 NASA authorization hearings, op. cit., p. 414.

24/ GAO, op. cit., p. 8.

25/ Global Crop Experiment Evaluated. NASA Press Release 78-179, November 17, 1978.

26/ 1978 NASA authorization hearings, op. cit., p. 420. GAO report, op. cit., p. 20.

27/ NASA press release, op. cit., p. 4.

2. Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS). Originally, USDA planned to implement an operational version of LACIE once the experimental program was completed. In 1977, however, USDA decided that a one-crop system was insufficient, and chose instead to pursue another technology development program with a broader scope. A USDA task force identified seven areas where information was needed that aerospace technology could wholly or partially satisfy. Known as the Secretary of Agriculture's initiative, these areas became the basis for the AgRISTARS program: 28/

1. Early warning of changes affecting production and quality of commodities and renewable resources;
2. commodity production forecasts;
3. land use classification and measurement;
4. renewable resources inventory and assessment;
5. land productivity estimates;
6. conservation practices assessment; and
7. pollution detection and impact evaluation.

In February 1978, the three agencies which had been involved with LACIE (USDA, NASA and NOAA) met with the Department of Interior and the Agency for International Development (AID) to discuss the possible development of a program based on the Secretary's initiative. A joint planning team drew up a proposal for a six year program (from FY80 through FY85), costing $317.3 million ($173.3 million from NASA, $124.2 million from USDA, and $19.8 million from NOAA -- the other two agencies were involved only in evaluating the utility of AgRISTARS products for their missions). An interagency agreement was written, and went into effect in January 1980 (AID did not sign the agreement because it felt its proper role was as an observer). 29/

28/ U.S. Department of Agriculture. Secretary's Initiative. Joint Program of Research and Development of Uses of Aerospace Technology for Agricultural Programs. February 3, 1978. [n.p.]

29/ Interagency Agreement Among the U.S. Department of Agriculture, U.S. Department of Commerce, U.S. Department of Interior, National Aeronautics and Space Administration, and the Agency for International Development for a Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS). 5 pp. Effective January 16,1980.

The program was organized into eight projects: (1) early warning crop condition assessment; (2) foreign commodity production forecast; (3) yield model development; (4) supporting research; (5) soil moisture; (6) domestic crops and land cover; (7) renewable resources inventory; and (8) conservation and pollution. NASA was designated the lead agency for projects 2 and 4, NOAA for project 3, and USDA for the remainder of the projects as well as for the entire AgRISTARS program.

In April 1979, after initial funding for AgRISTARS had been requested as part of the FY80 budget, the Senate Appropriations Committee requested its investigations staff to assess the AgRISTARS program proposal. The interagency agreement for the program had not been signed at this point, and the committee wanted an assessment of the program "to determine requirements, coordination with other Federal agencies, costs (USDA and all other agencies), program schedules, management, milestones, and feasibility." 30/

In its June 1979 report, the investigations staff was highly critical of certain aspects of the AgRISTARS program, particularly those relating to foreign commodity production forecasting (which the staff identified as projects 2, 4 and part of 3). Arguing that LACIE results had been poor, the investigations staff stated that the problems encountered in that program would be compounded when the same techniques were applied to other crops such as corn and soybeans, which are difficult to separate spectrally. The staff also commented that the yield models used for LACIE had been found to be severely limited, such that USDA was proposing over $50 million for R&D on new types of yield models in another segment of the AgRISTARS project, but that these new models would not be available for the commodity production forecasting project. Thus, the staff recommended that funding for that segment of AgRISTARS be denied. For the other segments of the program, the staff stated that cost-benefit analyses had not been conducted, and that the Committee on Appropriations might want to make such analyses a prerequisite for continued funding of AgRISTARS. 31/

The agencies responded to the questions raised by the investigations staff, and funding for the program was approved in FY80 and FY81.

30/ Investigations Staff, Committee on Appropriations, U.S. Senate. Proposed Joint Project for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS). Submitted to the Subcommittee on Agriculture, Rural Development, and Related Agencies, the Subcommittee on HUD-Independent Agencies, and the Subcommittee on State, Justice, Commerce, the Judiciary. Report No. 79-5. June 1979.

31/ Ibid., p. 4.

In January 1982, the involved agencies published an annual report detailing the accomplishments of the program to date. 32/

In FY82, however, budgetary problems began impacting the program. The budget revision for FY82 submitted by President Reagan shortly after he took office proposed that NASA's budget for AgRISTARS be reduced by $10 million in both FY81 and FY82. Since the program calls for pilot experiments to be conducted by NASA, followed by USDA applications tests, a slowing down of NASA's activities would affect the rest of the program. The revised NASA budget figures included stretching out the program by two years, to FY87. NASA's funding history for the AgRISTARs program is shown in Table 4. Although Congress appropriated the Reagan request of $23.1 million for FY82, the NASA operating plan for FY82 includes only $14.0 million for AgRISTARS.

The NOAA and USDA budgets for AgRISTARS are not identified separately in the budget requests of those agencies. NOAA has spent approximately $2.5 million per year on the program 33/, while USDA spent $10.8 million in FY80 and $12.8 million in FY81 and expects to spend $12.5 million in FY82 and $12.6 million in FY83. 34/ Funding beyond FY83 is uncertain.

3. Geological Applications Program. Landsat data can be used in a wide variety of geological applications, such as mineral and energy resource exploration (including oil, uranium, and geothermal energy), nuclear plant siting and waste disposal, charting glaciers and shallow seas, and geological mapping in general. 35/ Data from other satellites, such as Seasat and the Heat Capacity Mapping Mission are also used for geological purposes. As with other Landsat applications, the satellite data augments rather than replaces conventional techniques.

32/ U.S. National Aeronautics and Space Administation. Lyndon B. Johnson Space Center. AgRISTARS Annual Report - Fiscal Year 1981. Houston, Texas, NASA, January 1982.

33/ Jim Smith, National Oceanic and Atmospheric Administration, private communication, June 1982.

34/ Richard McArdle, U.S. Department of Agriculture, private communication, June 1982.

35/ See for example: Alexander F. H. Goetz and Lawrence C. Rowan. Geologic Remote Sensing. Science, Feb. 20, 1981, pp. 781-791; Floyd F. Sabins, Jr. Remote Sensing: Principles and Interpretation. San Francisco, W. H. Freeman & Co., 1978.

TABLE 4

NASA FUNDING HISTORY FOR THE AGRISTARS PROGRAM*
(in $ millions)

Fiscal Year	FY80 Budget Request	FY81 Budget Request	FY82 Carter Budget Request	FY82 Reagan Revised Request
FY80	16.0	16.0	16.0	16.0
FY81	28.0	33.2	31.4	21.4
FY82	32.3	38.4	33.1	23.1
FY83	34.2	40.9	33.6	23.6
FY84	35.1	40.9	36.9	26.9
FY85	11.4	14.0	29.4	19.4
FY86			15.9	5.9
FY87			8.7	8.7
TOTAL...........	156.9	183.4	205.0	145.0

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* Figures provided by NASA, June 3, 1981.

For example, by studying features on Landsat photographs, scientists can detect and map various rock formations that reveal areas of mineral deposits. Photographs of Kentucky and Tennessee led mining company representatives to at least seven promising areas of lead and zinc deposits which were more than 1,500 feet (457 meters) deep. The Landsat photographs had shown circular features, caused by color variations in vegetation growing above the rocks, which could not be discerned from the ground. The color variations were caused by ions from mineralized areas of subsurface rock (which were circular) migrating vertically and getting into the soil and water above, and eventually into the vegetation. The leaves would change color, and these variations were picked up by Landsat. 36/

In January 1981, NASA proposed a Geological Applications Program (GAP) as part of its FY82 budget request. The program was designed to assess the ability of Landsat and other remote sensing systems to discover oil and minerals, and was to have run for five years. Total cost of the program was estimated at $105 million; funding in FY82 was to have been $10 million. The Reagan Administration eliminated the program in its revised request to Congress in March 1982. The House Science and Technology Committee restored the $10 million when it reported out the NASA authorization bill for that year, stating that "The Committee believes that the importance of applying NASA's unique expertise in cooperation with private enterprise and other federal agencies to improve the effectiveness of global assessment, exploration and development of strategic minerals and energy sources through the use of space techniques supports initiation of this activity in fiscal year 1982." 37/

The Senate Commerce, Science, and Technology Committee did not recommend funding the program, nor did either of the appropriations committees, so the program has been terminated.

36/ Satellites Spot Minerals More Than 1,500 Feet Deep. Dallas Morning News, March 13, 1978.

37/ U.S. Congress. House. Committee on Science and Technology. Authorizing Appropriations to the National Aeronautics and Space Administration for Fiscal Year 1982; report to accompany H.R. 1257. Report no. 97-32. May 8, 1981. Washington, U.S. Govt. Print. Off., 1981. p. 12.

IV. MAKING THE LANDSAT PROGRAM OPERATIONAL

A. Summary

The major domestic issue which has enveloped the Landsat program since the beginning is how and when to "go operational" with the system, that is, to transition from research and development into an operational mode. The definition of the term "operational" has in itself been troublesome for the past several years, for although Landsat data has been used in an operational sense for a long time, it was felt that the technology and the system itself were still experimental. Thus it retained its funding and authorization status as an R&D program long past the time when many users felt that it was functioning operationally.

Another problem has been deciding whether the program should be transferred out of the Government and into the private sector or whether the Government should operate the space segment (the satellites and associated ground systems for command and control), with the private sector taking over the ground segment (data acquisition, processing, archival functions, and dissemination).

The formal acknowledgement of Landsat as an operational system, together with a commitment to program and data continuity, are needed a wide user base for the data. Users are concerned that they might invest thousands of dollars in equipment and training for utilization of Landsat data, only to have the R&D program terminated.

NASA's mandate is to perform research and development, not operate programs, so NASA's role was expected to phase out (except for advanced R&D) once the technical viability of the system and the utility of the data had been proven, just as the agency phased out of the weather satellite program.

The Executive Branch conducted several studies on issues involved in making the remote sensing satellite system operational. During the Carter Administration, three directives were issued which impacted the program in some way; the last of these (PD-54) transferred operational authority for the program from NASA to NOAA, although eventual transfer to the private sector was envisioned. The Administration hoped that this action would ease concerns about program continuity.

When President Reagan took office, however, the emphasis shifted to transferring operations to the private sector as soon as possible. NOAA announced that the launching of remote sensing satellites past Landsat D' would "depend on the private sector," once again calling into question the continuity of the program.

As 1981 ended, NOAA was preparing to take over operational responsibility for the Landsat program as of January 31, 1983 (six months after the launch of Landsat D), and the Cabinet Council on Commerce and Trade was deliberating on what the best method of transferring the Landsat program to the private sector would be, and whether meterological satellites should also be transferred to the private sector for management and operation.

B. Early Options

Prior to NOAA being selected as the manager of the operational Landsat system, several other Government agencies had been considered as a possible home for the operational program, including NASA (with a change in its organic act to provide for operating the program), the Department of Agriculture, and the Department of Interior. Another potential alternative was to create a new government agency either to operate just an earth resources satellite system or a larger agency (such as a Department of Natural Resources) which could incorporate other functions as well.

Legislative options for making the program operational have been debated for many years. The first bill to address the issue was introduced in 1973, one year after the launch of the first satellite, and it has been debated in every Congress since that time. The various bills are described in section 2; none has been reported from committee, however.

C. President Carter's Directives: Transferring Landsat to NOAA

During the Carter Administration, three major space policy directives were issued, each of which addressed the civil land remote sensing system in some respect. The first, PD-37, dealt with the relationship between the military and civil space programs; the second, PD-42, concerned goals for the civil space program; and the third, PD-54, transferred responsibility for Landsat from NASA to NOAA.

1. PD-37 and PD-42. The full texts of these two presidential directives are classified, but the White House released unclassified fact sheets outlining their major points, from which the following is excerpted.

The fact sheet on the first directive, PD-37, was released on June 19, 1978. Provisions of the policy directive relating to satellite remote sensing included the following:

- The United States will develop and operate on a global basis active and passive remote sensing operations in support of national objectives.

- The United States will encourage domestic commercial exploitation of space capabilities and systems for economic benefit and to promote the technological position of the United States; however, all United States earth-oriented remote sensing satellites will require United States government authorization and supervision or regulation.

- Advances in earth imaging from space will be permitted under controls and when such needs are justified and assessed in relation to civil benefits, national security, and foreign policy. Controls, as appropriate, on other forms of remote earth sensing will be established.

- Data and results from the civil space program will be provided the widest practical dissemination to improve the condition of human beings on earth and to provide improved space services for the United States and other nations of the world. 38/

Thus, the directive encouraged private sector interest in remote sensing satellites, while reserving the Government's right to supervise such activities. In addition, PD-37 set forth conditions under which the image resolution of remote sensing satellites could be improved, that is, "when such needs are jusitified and assessed in relation to civil benefits, national security, and foreign policy."

The directive also established a Policy Review Committee (Space) within the National Security Council which was immediately directed to conduct a study assessing the "needs and aspirations" of the civil space program.

The results of that study became the second Carter space policy directive, PD-42. The White House issued a fact sheet on PD-42 on October 11, 1978, stating, inter alia, that the President had reached the following decisions regarding remote sensing:

> Remote Sensing Systems. Since 1972 the United States has conducted experimental civil remote sensing through LANDSAT satellites. There are many successful applications and users, including Federal departments, other nations, a number of states, and a growing number of commercial organizations. The United States will continue to provide data from the developmental LANDSAT program for all classes of users. Operational uses of data from the experimental system will continue to be made by public, private, and international users. Specific details and configurations of the LANDSAT system and its management and organizational factors will evolve over the next several years to arrive at the appropriate technology mix, test organizational arragements, and develop the potential to involve the private sector.

38/ Office of the White House Press Secretary. Fact Sheet. June 19, 1978.

Integrated Remote Sensing System. A comprehensive plan covering expected technical, programmatic, private sector, and institutional arrangements for remote sensing will be explored. NASA will chair an interagency task force to examine options for integrating current and future systems into an integrated national system. Emphasis will be placed on defining and meeting user requirements. This task force will complete its review prior to the FY 1981 budget cycle.

The Private Sector. Along with other appropriate agencies, NASA and Commerce will prepare a plan of action on how to encourage private investment and direct participation in civil remote sensing systems. NASA and Commerce will be the contacts for the private sector on this matter and will analyse proposals received before submitting them to the Policy Review Committee (Space) for consideration and action. 39/

2. PD54 — Designating NOAA to Manage the Landsat System. Following the completion of the PD-42 study, the Administration turned its attention to dealing specifically with the issue of making the remote sensing program operational.

In November 1979, the Carter Administration announced its decision to assign responsibility for an operational civil remote sensing spacecraft system to NOAA, including management of all U.S. land, sea, and weather applications satellites and associated ground systems. The major elements of the policy, set forth in PD-54, were as follows:

- The formal establishment of an operational remote sensing system would commit the Federal Government to the development and maintenance of long-term systems, rather than a series of experimental missions, and should provide the user community with the assurance needed to invest the necessary funds for equipment and personnel training.
- The Administration would request FY81 funding for NOAA to study ways to further private sector opportunities in civil land remote sensing activities, through joint ventures with industry, a quasi-Governmental corporation, leasing, etc., with the goal of eventual operation of these activities by the private sector.
- In an effort to make certain that user needs were represented to NOAA, the Department of Commerce would establish and chair a program board for continuing Federal coordination and regulation of civil remote sensing activities. The involved Federal organizations

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39/ Office of the White House Press Secretary. U.S. Civil Space Policy. Fact Sheet. October 11, 1978. p. 2.

(such as the Departments of Defense, Interior, Agriculture, State, Transportation, and Energy, CIA, NASA, AID and EPA) would be represented. The National Governors' Association and the National Conference of State Legislatures would be invited to participate.

- o Separate management of civilian and military programs would continue. However, joint civilian/military activities would be pursued where both parties' objectives could best be met through this approach.
- o Users, who were then paying only for the costs of data reproduction, would have to bear a much greater share of the operational system costs. These costs would increase for both foreign and domestic users.
- o Recognizing that new remote sensing space spacecraft were under development in other countries, the Administration would contact these nations to find the best way to guarantee complementary systems.
- o NASA would remain responsible for spacecraft research and development. 40/

NOAA was chosen as the lead agency for a variety of reasons. An important factor was that NOAA's National Environmental Satellite Service has managed the operational weather satellite program for over ten years, unlike other contender agencies with no satellite programs. Also, consideration was given to the cost savings of a single agency approach. If the Department of Interior or the Department of Agriculture had been given reponsibility for Landsat, and weather and ocean spacecraft systems remained in NOAA, Federal responsibilities in the overall management of remote sensing satellites would have been split, thereby increasing costs. Finally, NOAA, unlike the Departments of Interior or Agriculture, had no Landsat programs which could conceivably prejudice its design of future spacecraft systems to serve in-house needs at the expense of other user needs.

The recommendation of the Space Policy Review Committee was not unanimous. Among those who approved of NOAA as the lead agency were NASA and the Department of Agriculture, the prime user of Landsat data. The Department of Interior and AID maintained that the Department of Interior should have been given management responsibility because of its extensive experience in data processing and distribution.

40/ Office of the White House Press Secretary. Fact Sheet. November 20, 1979.

3. Implementation of PD-54. Though the Carter Administration had outlined the concept for the operational remote sensing satellite system and called for the program's transfer to NOAA, there were a number of issues which awaited further definition. A plan for the transition of management from NASA to NOAA had to be prepared, and technical requirements for an operational system had to be established. Among the questions to be resolved were: the number of satellites needed to provide useful, repetitive coverage with appropriate provisions for backup satellites in the event of equipment failure, the rapidity with which useful data products could be made available to users, the usefullness of data format, and the manner in which technical innovations would be introduced into the system.

At hearings in the summer of 1980, NOAA submitted a discussion document to Congress entitled Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options. 41/ The document contained some policy and technical options related to implementing an operational system, but noted that decisions on those options would probably await the FY82 budget deliberations, and that until decisions on the design and funding of a fully operational program were reached, the Federal government would depend on the NASA-planned Landsat D system.

The NOAA plan envisioned a two phase program for transferring land remote sensing satellites into the private sector. During the first phase, the program would be based on Landsat D and any required follow-on satellites, to ensure continuity of data.

Under this scenario, NOAA will assume responsibility for Landsat's space segment on January 31, 1983, six months after Landsat D is launched. Initially, NOAA will only have responsibility for the Landsat D multispectral scanner, since the thematic mapper is still experimental. NASA will retain responsibility for the thematic mapper for approximately 30 months, after which NOAA will assume responsibility for that instrument as well. Responsibility for data archiving and distribution at the EROS data center will be transferred to NOAA during 1983-4; the Department of the Interior will retain responsibility for research related to Landsat applications and conducting training program for utilizing Landsat data, since these functions primarily service the missions of the Department of Interior. As noted earlier, NOAA has indicated that costs for Landsat data will rise as of October 1, 1982 in keeping with the provisions of PD-54 regarding users paying more for their share of the operational system.

41/ U.S. Department of Commerce. National Oceanic and Atmospheric Administration. Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options. Rockville, Md., NOAA, June 20, 1980. 130 pp.

NOAA estimated that the second phase of the program, a fully operational system based on advanced technology (multilinear arrays) and designed to meet user needs, could not be ready before 1989. The plan anticipates private sector operation of the fully operational system, and NOAA outlined several institutional alternatives for achieving this goal.

NOAA indicated in this document that it felt it did not have the requisite authority to conduct the Landsat program. Such language is expected to be included in FY83 funding legislation.

NOAA has announced plans to establish a Land Remote Sensing Satellite Advisory Panel to advise NOAA on how to manage the Landsat program. Its members are expected to come from industry, State government, and the academic community.

D. Congressional Efforts to Establish an Operational Landsat System.

Legislation was first introduced in Congress to establish an operational Landsat system in 1973, one year after the launch of Landsat 1 (then called the Earth Resources Technology Satellite 1 — ERTS 1). Between 1973 and 1981, nine bills dealing specifically with the operational Landsat question (all in the Senate) and six other bills dealing more generally with U.S. space policy and including reference to remote sensing issues (in the House and Senate), have been introduced. None has been reported from committee.

1. 93rd Congress (1973-1974). Two bills were introduced in the 93rd Congress providing for institutional arrangements for an operational Landsat system. The first, S. 2350, was introduced by Senator Frank Moss, then Chairman of the Senate Committee on Aeronautical and Space Sciences [42] on August 3, 1973. The second, S. 3484, was introduced by Senator James Abourezk on May 13, 1974.

Hearings on both bills were held by the Senate Committee on Aeronautical and Space Sciences in August and September 1974. [43] The organizations established by both bills would have been responsible for the operation of an Earth Resources Observation System, and for determining improved means of data acquisition and interpretation. Both bills provided that NASA would design, develop, and operate the space segments of the respective earth resources satellite systems.

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[42] This committee was abolished at the beginning of the 96th Congress and its functions were transferred to the Senate Commerce, Science, and Transportation Committee.

[43] U.S. Congress. Senate. Committee on Aeronautical and Space Sciences. Earth Resources Satellites. Hearings, 93rd Congress, 2d session. August 6, 8, 9 and September 18, 1974. Washington, U.S. Govt. Print. Off., 1974.

The major difference between the bills was that S. 2350 designated NASA as the lead agency for the system, while S. 3484 assigned that responsibility to the Department of Interior. The bills seemed to reflect different philosophies; in assigning the lead role to NASA, S. 2350 emphasized the technical aspects of the Landsat program, while S. 3484 focussed on the needs of the user community.

The Moss bill (S. 2350), would have required NASA to establish an Office of Earth Resources Survey Systems with primary responsibility for transforming remote sensing technology into an operational reality. Thus, in addtion to its existing responsibility for launching the satellite, controlling the satellite, and receiving satellite data, NASA would also have had responsibility for data dissemination.

At the hearings, a major criticism of the bill was its artifical segregation of earth resources activities from closely related satellite applications programs within NASA such as meteorology and oceanography. In establishing a separate office within NASA, it was argued that the legislation would unduly reduce NASA's flexibility to organize itself most effectively to carry out its functions

The bill also elicited unfavorable comments for assigning NASA the responsibility and authority for data interpretation and dissemination. The criticism was that these functions would be more appropriately left to the users and user agencies which are, by virtue of applications experience in their respective disciplinary fields, more competent to meet user requirements. Several experts felt that NASA's responsiveness to user requirements could be assured by other, more effective methods such as increased interaction between NASA and the user community.

Concern was also expressed that if the Landsat system were to be declared operational, NASA would be unable to secure the appropriate radio frequencies. Critics of the bill pointed to the assignment of three operational frequencies to the Department of the Interior for an Earth Resources Observation System by the Office of Telecommunications Policy. 44/ However, according to Dr. James Fletcher, then NASA's Administrator, "Frequencies are assigned to functions or services, not agencies. Therefore, frequency allocations do not impact the policy on which agency should manage the space segment of a future operational system." 45/

44/ The Office of Telecommunications Policy was subsequently abolished and many of its functions were transferred to the National Telecommunications and Information Agency in the Department of Commerce.

45/ Earth Resources Satellites hearings, op. cit., p. 186.

The Abourezk bill (S. 3484) would have established an Earth Resources Observation Administration within the Department of Interior. Like the Moss bill, S. 3484 was attacked because it excluded related systems such as meteorological satellites from its definition of earth resources satellite systems. The limitation of NASA's R&D in earth resources to activities supported and funded by the Department of Interior was thought to be a peculiar compartmentalization of the space effort which would unnecessarily complicate the total space program and thereby be contrary to the National Aeronautics and Space Act of 1958. In addition, some witnesses commented on the inappropriateness of having the Department of Interior, with no overall technical systems design experience, direct NASA's R&D efforts.

Both bills omitted provisions concerning the role of the private sector and allocation of costs and reimbursements for services.

In general, the consensus seemed to be that the interests of a successful Landsat program would best be served by assigning to NASA the responsibility, authority, and resources for the research, development, and operation of the Earth Resources Satellite System to the point of delivering to user agencies a standard digital tape product; and that the authority, responsibility, and resources for primary data archiving and dissemination, for standard processing (digital and photographic), and research and development in image interpretation should reside with the user agencies (which was essentially a description of the existing arrangement).

2. 94th Congress (1975-1976). Following the aforementioned hearings, it was determined that Landsat was not ready to become an operational program, and a new bill, S. 156, was introduced in the first session of the 94th Congress to provide for continuation of Landsat in an experimental mode. The provisions of S. 156 were later incorporated into NASA's FY76 authorization bill (H.R. 4700).

a. S. 3759. In the second session of the 94th Congress, Senator Moss introduced another bill for establishing an operational earth resources satellite system (S. 3759, August 24, 1976). The bill incorporated a goal increasingly applied to space applications programs -- the evolution to self sufficiency. The bill was based on a report prepared for the committee by Charles Mathews, who had formerly served as NASA's associate administrator for applications. 46/

46/ U.S. Congress. Senate. Committee on Aeronautical and Space Sciences. An Analysis of the Future Landsat Effort. Committee Print. 94th Congress, 2d session. Washington, U.S. Govt. Print. Off., 1976. 38 pp.

The legislation would have established a mechanism whereby private industry would be encouraged to assume an increasingly larger role in the support of remote sensing technology. Simultaneously, some Government involvement would have been retained to support R&D on advanced systems and to provide safeguards to preserve the system's integrity and to provide reassurance to foreign nations that might be apprehensive about the commercialization of world-wide satellite imagery.

Specifically, the bill would have established an Office of Earth Resources Policy in the Executive Office of the President under a Director appointed by the President subject to Senate confirmation. The new presidential office would have formulated requirements for a private earth resources corporation, and together with the corporation, would have operated the Global Resources Information System. Initially, the corporation would have functioned only as an information distribution organization, but eventually would have assumed all Landsat activities except spacecraft research and development. Spacecraft development would have remained with NASA.

This move of the experimental Landsat program to a fully operational system would have been accomplished in three phases under the terms of the bill. Phase I was intended as a validation phase, encompassing the period from when the bill was passed to approximately 1985. Institutional and system arrangements would have been formulated during this period, with the Office of Earth Resources Policy having responsibility for overall guidance. During this phase, NASA would have retained responsibility for managing the orbiting spacecraft, while the Department of Interior's EROS data center would have continued its functions related to Landsat data and image processing. The corporation would have been responsible for data dissemination, and private industries would have been invited to increase their participation in the Landsat program.

In Phase 2, the corporation would have taken control of every element of the system, including management of the spacecraft and central processing of the data and imagery. At this stage, an increasing number of private industries were expected to become involved in various aspects of the program.

Phase 3 operations would have begun in 1990. At this point, it was expected that the system would be nearly self-sufficient, and many industrial firms would be involved, with a high degree of business competition for the same services. The bill assumed that by this time, the user market would have solidified and increased substantially. Industry was expected to sponsor R&D with its own resources.

No action was taken on the bill.

b. 1976 GAO Report. On January 30, 1976, the General Accounting Office (GAO) released its first report on Landsat. 47/ The report was prepared at the request of the Chairman of the Subcommittee on HUD-Independent Agencies of the Senate Appropriations Committee, and was intended to provide general information to assist the Congress in exercising its legislative and review functions.

The report concluded, inter alia, that there should be a long range plan which includes user requirements "so that it can be determined when the state of the art provides the users with an adequate capability for determining success or failure of the LANDSAT project." GAO recommended that NASA initiate development of a plan including requirements, milestones, and dates for evaluating progress in determining when and if the program should become operational. Specifically, GAO stated that such a plan address "(1) the assignments of roles and responsibilities to the involved [Government] agencies, (2) interrelationships among oceanographic, meteorological and earth resources satellite systems, (3) alternative organizational arrangements for operational systems reflecting differing degrees of Government, private sector and international participation, and (4) estimated resource and funds requirements to be filled by the Federal Government. 48/

3. 95th Congress (1977-1978). During the 95th Congress, three bills were introduced in the Senate regarding an operational Landsat system and hearings were held, but none was reported from committee. No House bill was introduced, but hearings were held and a committee print listing findings and recommendations was issued. Two bills dealing in general terms with space policy, including remote sensing, were introduced in the Senate, but no action was taken on either measure. The General Accounting Office (GAO) released two studies on Landsat, in 1977 and 1978 respectively.

a. S. 657. On February 7, 1977, a bill to etablish an Earth Resources and Environmental Information System was introduced by Senator Wendell Ford (S. 657).

Under the terms of this bill, NASA would have been designated manager of the space segment -- the satellites and associated ground equipment for command and control of the satellites. The Secretary of Interior would have been designated as the manager of the data handling segment, that portion of the system that receives data from the satellites, processes the data, and disseminates the resulting products to users.

47/ U.S. General Accounting Office. Land Satellite Project; study by the staff of the U.S. General Accounting Office. Washington, GAO, January 30, 1976. 42 p. PSAD-76-74.

48/ Ibid., pp. 39-20.

The bill would have required the Secretary of Interior to furnish the system data and information to Government and private users, domestic and foreign, on an equal basis. In addition, the Department of Interior would establish regional distribution centers in the United States to provide ready access to the information. The Director of the Office of Science and Technology Policy (OSTP) in the Executive Office of the President would have coordinated and overseen the development, validation, and operation of the system.

According to the provisions of the bill, NASA would have been given seven years to establish an operational space segment, but would have permanently retained responsibility for all R&D related to the system.

Hearings were held on S. 657 in May and June, 1977. 49/ One major criticism of the bill was its omission of the Department of State in its arrangements for data dissemination programs for foreign nations. Testimony from the OSTP presented the Administration's view that Landsat techology was not yet ready to form the basis of an operational system. No further action was taken on the measure.

b. 1977 GAO Report. The General Accounting Office released its second study of the Landsat program shortly before the hearings. 50/ GAO noted that in response to a recommendation made in its first report, NASA had begun to develop a plan for evaluating progress toward the goal of deciding if and when to make the Landsat program operational, but that no agreement had been reached among the users of what performance objectives had to be achieved in the 1981-86 time period to justify an operational system.

GAO concluded that it was premature to make Landsat operational, and suggested that a study be prepared to assess the benefits to be gained versus the expenses and resources required to establish the system. The agency also concluded that a clear statement of Government policy was required regarding support of an operational Landsat system, including consideration of technical, political, economic, institutional, and international issues. GAO recommended that OSTP, in conjuction with NASA and other cognizant Federal agencies, study the issues involved and recommend a Government policy role in satellite remote sensing.

49/ U.S. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Science, Technology, and Space. Earth Resources and Environmental Information System Act of 1977. Hearings, 95th Congress, 1st session, May 24, 25, June 13 and 14, 1977. Washington, U.S. Govt. Print., Off., 1977. 352 pp.

50/ U.S. General Accounting Office. Landsat's Role in an Earth Resources Information System; report to the Congress by the Comptroller General of the United States. Washington, GAO, June 10, 1977. 37 pp. PSAD-77-58.

c. 1977 House Science and Technology Committee Hearings. Although no specific legislation related to establishing an operational earth resources satellite system had been introduced in the House, the House Science and Technology Committee's Subcommittee on Space Science and Applications held hearings on this general topic in June 1977. 51/

Charles Mathews, who had prepared a report for the Senate committee in 1976, prepared two additional reports for the House committee in 1977, which served as the basis for the hearings. The first dealt with defining an earth resources information system, while the second addressed institutional arrangements required for transitioning from an experimental to an operational system.

In the latter paper, Mathews concluded that NASA should be responsible for the space segment, while noting that this should not preclude commercial ventures of an ancillary nature, and that the Department of Interior's EROS data center should operate a centralized data handling segment. Information extraction and interpretative services were already highly decentralized, according to Mathews, and open to all sectors involved with earth resources satellite services. Mathews also commented that NASA and the EROS program should sponsor application demonstrations in close cooperation with users. Testimony was received from a wide variety of witnesses, including Government and the private sector.

In November 1977, a committee print was released based on the hearings which listed 25 findings and 10 recommendations. The recommendations were as follows:

- The executive branch should provide a mechanism to assure the participation of all elements of the user community in all phases of development of an earth resources information system.
- Within the next 12 months the Federal Government should commit to a 5-year earth resources information system validation program with a stated goal of an orderly transition to an operational system at the end of the validation program.
- Within the next 18 months, the Office of Science and Technology Policy should report to the Congress a specific program plan for accomplishing the Earth resources information system validation program.

51/ U.S. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. Earth Resources Information System. Hearings. 95th Congress, 1st session, June 21, 22, 23, 1977. Washington, U.S. Govt. Print. Off., 1977. 672 pp.

- The executive branch should study the various institutional alternatives, establish the criteria from which to choose an institutional alternative, and recommend to the Congress the preferred institutional alternative for an earth resources information system. Prior to such recommendation, no promising institutional alternative should be foreclosed.

- The executive branch should study and recommend to the Congress a pricing policy which encouraged competitive ground operations and encourages market development.

- The executive branch should study and recommend to the Congress an approach that would enable early transition of the data handling and data dissemination activities to the private sector.

- The Federal Government should provide a clear understanding as to what are the government's roles and what are the private sector roles with a clear commitment of the Government to the functions for which it is responsible.

- The United States should continue to provide and encourage the development of expertise in foreign countries and provide for open access to the data from an earth resources information system.

- The executive branch should clarify the roles of the Federal agencies by designating a lead agency and assigning responsibilities.

- Within the next 12 months, the executive branch should establish a working board of participating members with a designated lead agency serving as chairman. The Office of Science and Technology Policy should submit to the Congress an organization plan for establishing such a working board. [52]

d. 1978 GAO Report. In April 1978, GAO released the third in its series of reports on the Landsat program. [53] GAO noted that the

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[52] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. Earth Resources Information Systems. Committee Print. 95th Congress, 1st session. November 1977. Washington, U.S. Govt. Print. Off., 1977. pp. 1-5.

[53] U.S. General Accounting Office. Landsat Policy Issues Still Unresolved; Report to the Congress by the Comptroller General. Washington, GAO, April 17, 1978. PSAD-78-58. 27 pp.

OSTP was considering some technical and funding issues related to Landsat D and was planning to create a Cabinet level policy group to study broader issues regarding an operational remote sensing satellite system. The report recommended that the Director of OSTP periodically inform NASA as to the status of these activities.

e. S. 3589. Introduced by Senator Stevenson on October 12, 1978, the Earth Data and Information Service Act of 1978 would have established an Earth Data and Information Service as a separate office within NASA to manage the spacecraft, ground systems, and data processing segments of an operational remote sensing satellite system. The Administrator of NASA would have been given authority to establish and manage the Service, while direct operational responsibility would have rested with the General Manager of the Service, who was to be appointed by the President by and with the advice and consent of the Senate. Although the Service was to be separated from NASA's research and development function, a principle reason for choosing NASA for this assignment was the importance of maintaining close ties between operational management of the systems and continuing research and development activities.

The Service would have been directed to meet user needs at terms to be established by the Administrator. Income eventuallv would have covered the costs of maintaining and operating the Service.

An interim period of seven years was to be used for developing the institutional, financial, technical, and marketing capabilities needed to bring the Service to full operational status. During this interim period, the President would have been directed to prepare and transmit to the Congress recommendations on the appropriate organizational entity to continue an operational service after the interim period.

There was no action on this measure. The bill was reintroduced in the 96th Congress as S. 663.

f. S. 3625. Senator Schmitt introduced S. 3625 on October 14, 1978. Entitled the Earth Resources Information Satellite Act, the bill would have established a policy to create a commercial earth resources satellite corporation which was to be made operational as soon as possible and provide the widest possible participation by private industry, on a nondicriminatory basis.

The bill would have created the Earth Resources Information Satellite Corporation, controlled by a 17-member Board of Directors. Three of the members would have been appointed by the President; the Departments of Agriculture, Commerce, and Interior, and the National Association of State Governors were each to appoint one member; and ten were to be elected by the stockholders. The corporation was authorized to issue stocks carrying voting rights; wide distribution to the American public would have been encouraged.

The corporation would have had authority to market raw and preprocessed data on earth resources, and to own and operate the earth resources satellites, ground receiving stations, and information distribution centers for the provision of raw and preprocessed data. The corporation would have been regulated by the Federal Communication Commission, which was charged with ensuring effective competition by, among other things, consulting with the Small Business Administration to ensure that equitable opportunities were provided for small businesses and to insure that the opportunity to purchase Earth resources data, under just prices, would be available to all persons and organizations.

The bill would have had NASA furnish launch services to the corporation on a reimbursable basis, conduct research and development to refine the capabilities of the system, and coordinate activities of the various governmental agencies that were involved with or benefitted from the corporation.

There was no action on this measure. The bill was reintroduced in the 96th Congress as S. 875.

g. Space Policy Legislation: S. 3530 and S. 3599. At the end of the 95th Congress, following the release of President Carter's directive on civilian space programs (PD-42), Senators Stevenson and Schmitt introduced bills providing alternatives to the President's space policy. Because the bills were introduced so late in the session, their primary purpose was seen as serving as a discussion point, from which future legislation might be introduced. In fact, both bills were revised and reintroduced in the 96th Congress.

Since specific legislation had been introduced already concerning operational remote sensing satellites systems, these bills dealt with the issue only peripherally. The Stevenson bill, S. 3530, concerned the next ten years in space, and emphasized the role of the private sector. Among the provisions of the bill was the goal of establishing and operating a system of remote sensing of the Earth's resources, environment and related conditions. The Schmitt bill, S. 3599, took a longer view of space activities and covered the next thirty years in space. One goal included in the bill was to establish a World Information System by the year 1990 which would have included an operational earth resources monitoring system for collecting and making available data necessary for maximum efficiency and environmentally sound utilization of natural and agricultural resources on Earth.

No action was taken on either measure.

4. 96th Congress (1979-1980). During the 96th Congress, three Senate bills dealing specifically with an operational remote sensing satellite system were introduced and hearings were held on two of the measures. Although there was no similar House bill, hearings were held by the Science and Technology Committee.

In addition, two Senate bills and two House bills were introduced dealing more generally with the subject of space policy which included references to remote sensing from space. Hearings were held on the Senate space policy bills, and the House held hearings on space policy although they did not directly relate to the legislation that had been introduced.

a. Space Policy Legislation: S. 212 and S. 244. Senators Schmitt and Stevenson reintroduced their space policy bills from the 95th Congress soon after the 96th Congress convened. The Schmitt bill, S. 212 (January 24, 1979) was a substantial revision of the earlier measure, although the sections related to remote sensing remained relatively the same. S. 212 declared that it was in the national interest to establish a U.S. space policy directed toward creation of a world information system during the 1980's that could consist of "permanent, generally self-financing services in telecommunications, weather and ocean forecasting, [and] Earth resources sensing." In addition, the new measure included language from the previous version of the bill regarding establishment of a World Information System.

The new Stevenson bill, S. 244 (January 29, 1979) included generally the same provisions related to remote sensing as had been in the earlier version.

Hearings were held on the bills on January 25, 31 and February 1, 1979, but no further action was taken. 54/

b. 1979 House Science and Technology Committee Hearings on Space Policy. Although no space policy legislation had been introduced in the House at the time, the Committee on Science and Technology held one day of hearings on civilian space policy in February 1979. The hearings addressed space policy in general, not specifically the issue of remote sensing. 55/

c. S. 663 and S. 875. Introduced by Senator Stevenson, S. 663 (March 13, 1979) was essentially identical to S. 3589 which had been introduced in the 95th Congress. Similarly, S. 875 (April 4, 1979) introduced by Senator Schmitt, was virtually identical to S. 3625 from

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54/ U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Science, Technology, and Space. U.S. Civilian Space Policy. Hearings. 96th Congress, 1st session, January 25, 31, and February 1, 1979. Washington, U.S. Govt. Print. Off., 1979. 423 pp.

55/ U.S. Congress. House. Committee on Science and Technology. Oversight: President's Civilian Space Policy. Hearing. 96th Congress, 1st session, February 14, 1979. Washington, U.S. Govt. Print. Off., 1979. 66 pp.

the 95th Congress, with one notable exception. The earlier bill would have required the Earth Resources Satellite Corporation to be made operational "as soon as possible," while the new bill stated that it be made operational no later than two years after the enactment of the bill.

Hearings were held on these two bills in April and July 1979. [56] Testimony was received from a variety of Government and private sector individuals, many of them users of Landsat data. The Administration position was presented by Dr. Frank Press, Director of OSTP. Press reminded the committee that President Carter had asked NASA to chair an interagency task group to examine options for integrating current and future potential systems, including technical, programmatic, and institutional arrangements. In addition, Carter had directed NASA and the Department of Commerce to actively explore private sector interest, roles and conditions of Government control vis a vis an operational remote sensing system. Press expressed the Administration's position that the executive and legislative branches were on a convergence path (i.e., that the proposed legislation was similar to what the Administration was doing already), and legislation was therefore not needed at that time.

No further action was taken on either bill.

d. 1979 and 1980 House Science and Technology Committee Hearings on Operational Civil Remote Sensing Systems. The House Science and Technology Committee held two sets of hearings on the topic of operational remote sensing systems during the 96th Congress although there was no legislation introduced in the House to accompany the hearings. The first set was held in May 1979, prior to President Carter's designation of NOAA to take over the Landsat program, and the second was held in June and July 1980 after that action had been taken.

The 1979 hearings [57] were held to examine whether or not the executive branch had implemented any of the committee's recommendations made in November 1977. At the hearings, John McLucas, representing COMSAT, stated that his organization was prepared to invest considerable resources in earth remote sensing technology and to assume reasonable risks in making the program commercially successful. McLucas outlined a plan envisioned by COMSAT to transition land remote sensing from the Government into the private sector in which NASA would continue to operate the program for an interim period of time while COMSAT, working with NASA, would define a system for the future based upon user requirements.

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[56] U.S. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Science, Technology, and Space. Operational Remote Sensing Legislation (Parts 1 and 2). Hearings. 96th Congress, 1st session. Part 1: April 9 and 11, 1979. Part 2: July 31, 1979. Washington, U.S. Govt. Print. Off., 1979.

[57] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. Earth Resources Data and Information Service. Hearings. 96th Congress, 1st session, May 2 and 3, 1979. Washington, U.S. Govt. Print. Off., 1979. 219 pp.

In the long run, NASA would continue to perform R&D for advanced technology, but the private sector would operate the system. McLucas stressed that the Government would be expected to purchase its land remote sensing data from the private sector operators, and not launch its own competitive system. In addition, the Government would be expected to guarantee a minimum amount of services and data that it would procure each year. McLucas estimated that the Government would have to make a commitment to purchase between 65 and 75 percent of the revenue requirements of the system.

Administration witnesses testified that studies were on-going within the Executive Branch on how to make the Landsat system operational.

In the summer of 1980, the committee again held hearings, this time to examine plans for the transition of the Landsat program from NASA to NOAA. 58/ Congress had been awaiting the plan for the NOAA transition since the President's announcement of the transfer in November 1979. NOAA submitted a policy document outlining the issues involved in such a transition shortly before the hearings ("Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options," cited previously).

The first two days of hearings focussed on the role of the private sector in the operational remote sensing system. Witnesses from the private sector agreed that a larger private sector role in the program was desirable, but disagreed on whether that meant the entire system should be operated outside the Government, or only the ground segment.

Following up on its testimony from the previous year, a COMSAT representative, John Johnson, testified that his company had recommended that NOAA define the Government's needs for land remote sensing data and determine the cost of establishing a Government owned system to meet those needs and make that data available to the private sector so that interested companies could then make a proposal to provide those services, presumably at a lower cost.

58/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications and Subcommittee on Natural Resources and Environment. Hearings. 96th Congress, 2d session, June 24, 25, and July 29, 1980. Washington, U.S. Govt. Print. Off., 1980. 315 pp.

The third day of hearings, a month later, took testimony from the Executive Branch. Speaking on behalf of NOAA, Richard Frank noted that in the time since the announcement of NOAA as the operational agency for Landsat, the agency had begun extensive efforts to involve non-Federal users and potential private sector system operators in developing its transition plan. He announced NOAA's plan to establish a land remote sensing satellite advisory committee to continue to receive advice from the private sector.

Frank stated that NOAA envisioned a two phase development plan for a civil operational land remote sensing system. The first phase would be an interim system consisting of Landsat D with any necessary follow-on satellites and ground system improvements. This would provide continuity for users of the system. During this phase, advanced remote sensing technology (multilinear arrays) would be developed for the second phase of the program to meet higher performance standards. He anticipated that such a high quality system could be in place no earlier than 1989. This latter system, according to Frank, had been designated the "fully operational system." NOAA would manage the interim operational system with the goal of eventual private sector ownership and operation of the fully operational system.

NASA was represented by Anthony Calio, who stated that under the transition plan, NASA would remain responsible for development of new and advanced technology, satellite systems and prototype operational spacecraft, and where appropriate, would continue to develop and share with users technologies for acquiring, processing, and interpreting remote sensing data.

e. Space Policy Legislation in the House: H.R. 4316 and H.R. 6304. Although no legislation specifically concerning operational land remote sensing satellite systems was introduced in the House during the 96th Congress, two bills dealing with space policy in general were introduced.

On June 5, 1979, Representative Robert Dornan introduced H.R. 4316, the National Space Policy Act of 1979. The bill was identical to S.3599, the space policy bill originally introduced by Senator Schmitt in the 95th Congress. It included the goal of establising a World Information System by the year 1990, incorporating an operational earth resources monitoring system.

Representative George Brown introduced his National Space Policy Act of 1980, H.R. 6304, on January 28, 1980. Based primarily on Senator Stevenson's bill (S. 244), the Brown bill had several changes which emphasized international remote sensing operations. The bill called specifically for the development of an improved capability for interpretation and rapid utilization of remote sensing data and the investigation and determination of institutional arrangements for international cooperation in the use of remote sensing systems, including the fullest possible declassification of satellite monitoring and surveillance data, and provision for increased training in data interpretation.

No hearings were held specifically on either of these bills, although the House Science and Technology Committee held general hearings on space policy in July 1980. 59/ These hearings did not focus on remote sensing.

f. S. 3169. In the closing days of the 96th Congress, Senator Stevenson introduced S. 3169, the Earth Data and Information Service Act of 1980. The bill was essentially the same as S. 663, but would have established the Service within NOAA instead of NASA. No action was taken on the bill.

5. 97th Congress, 1st Session (1981). During the first session of the 97th Congress, no legislation concering an operational remote sensing satellite was introduced in either the House or Senate. Joint hearings were held on this topic in July 1981. Two space policy bills have been introduced, and the House committee held space policy hearings in the fall of 1981, but these did not focus on remote sensing systems.

a. 1981 Joint House/Senate Hearings. On July 22 and 23, 1981, the Senate Commerce, Science, and Transportation Committee's Subcommittee on Science, Technology, and Space jointly held hearings with the House Science and Technology Committee's Subcommittee on Space Science and Applications on civil land remote sensing systems. 60/

The most notable aspect of these hearings was the proposal by COMSAT, represented by its President, Joseph Charyk, that the Government make COMSAT the designated entity for taking over remote sensing systems. The COMSAT proposal included not only land remote sensing, but weather satellites as well. Charyk explained that the advantages of combining the two systems resulted from economies of scale by eliminating duplicate facilities and from the nature of the data which would be produced. The COMSAT proposal, called EARTHSTAR, would have effected transfer of remote sensing satellite systems to the private sector by purchase of certain elements of the GOES, NOAA and Landsat satellites and certain related ground equipment from the Government. Charyk averred that this

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59/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. United States Civilian Space Policy. Hearings. 96th Congress, 2d session, July 23, 24, 1980. Washington, U.S. Govt. Print. Off., 1980. 246 pp.

60/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Science, Technology, and Space. Civil Land Remote Sensing Systems. Hearings. 97th Congress, 1st session, July 23, 23, 1981. Washington, U.S. Govt. Print. Off., 1981. 366 pp.

proposal could save the Government "several hundred million dollars in operating costs" and "users would benefit from our plans to improve the timeliness of data and increase the diversity of data products." He also noted that a "Government commitment to procure its data and data products from the commercial system is required." 61/

Representatives of the American Science and Technology Corporation (ASTECH) explained their proposal to take over operation of remote sensing satellites. According to Dr. Norman McLeod, the ASTECH proposal, called FOODSAT/PETROSAT, would focus on providing information for managing those resources. The concept envisions operation of the space and ground segments by the private sector, with continued R&D by NASA, NOAA, and the university research community. ASTECH would launch several small satellites, using multispectral scanners, into sun-synchronous orbits to produce many observational opportunities in the morning and afternoon hours. Data would be received at existing Landsat ground stations and processed with existing data processing systems. The satellites would use existing technology to meet the needs of an existing market, according to McLeod, and therefore could be expected to produce an adequate return without direct government subsidies. McLeod emphasized the need for a guarantee that the government would not launch competing systems, however, and listed several areas in which government support would be needed, such as in international marketing through embassy support of visits to foreign capitals, continued basic and applied research in the Government and universities, and the continuation of training programs.

Thomas Anderson, representing the National Conference of State Legislatures, expressed concern that if the private sector took over complete operation of the program, costs could rise prohibitively. He added that it might be possible to turn over the ground segment without adversely affecting data prices, and that "it may well be that the time is right to transfer this segment into private hands." 62/

Michael T. Halbouty, a geologist and engineer, asserted that Landsat should have been declared operational years ago so that the technology could have been systematically upgraded to provide data on a routine and efficient basis, and that if such a commitment had been made by the Government, the private sector would be involved in directly marketing Landsat data and perhaps leasing part of the Landsat system today. The designation of NOAA to manage the transition of Landsat to an operational status "compounded and confused" the situation, according to Halbouty, and "it is time to get back

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61/ Ibid., pp. 260-272.

62/ Ibid., p. 73.

on the right track." 63/ He recommended that Landsat be declared operational; that the Government be responsible for the high risk elements of the operational program (adding that this is the state of most of the program now, but the Government's share would decline in the future); that industry participation be encouraged by broad, simple legislation and streamlining Government bureaucracy so that industry has to interface with only one agency; and that single agency be responsible for working out details of the institutional and legal framework for maximizing industry involvement. He also urgently recommended that the United States launch a solid state stereo remote sensing satellite.

General Electric, Co., which constructs the Landsat satellites for NASA, was represented by Mr. A.J. Rosenberg, who expressed concern about the lack of commitment to continuity for the Landsat program. In his opinion, only one organization, the U.S. Government, can make such a commitment, and once continuity is assured, then other issues, such as the feasibility of operating the system commercially, can be addressed. He expressed doubts that the system could be operated commercially at this time, and urged that the focus be on preserving "the integrity of the system we have" and protecting "our national investment." 64/

Other witnesses complained that there still was no assurance of continuity of the system, and that without such assurances, the United States could lose out on satellite remote sensing entirely, because other countries are developing similar systems.

b. Space Policy Legislation: H.R. 3712 and H.R. 4286. Two general space policy bills have been introduced. The first, H.R. 3712, was introduced by Representative George Brown on May 28, 1981. The bill is identical to H.R. 6304 from the previous Congress.

On July 28, 1981, Representatives Newt Gingrich introduced H.R. 4286. the National Space and Aeronautics Policy Act of 1981. The bill is patterned after the Schmitt bill from the 96th Congress (S. 212), and its provisions regarding remote sensing are the same.

No hearings have been held on either bill as of the end of 1981. General space policy hearings were held by the House Science and Technology Committee in September 1981, but these did not focus on remote sensing. 65/

63/ Ibid., p. 208.

64/ Ibid., p. 235.

65/ The hearings were held on September 21,22, and 23, 1981 by the Subcommittee on Space Science and Applications. They had not been published as of December 1981.

E. User Requirements

In developing an operational system, it is important to identify the needs of potential users of the data so that the system will meet a broad scope of requirements. One criticism of NASA's experimental Landsat program is that is was designed with the needs of the agricultural community in mind, and not other sectors, such as geology.

NOAA is attempting to remedy the situation for the operational Landsat program, and as noted earlier, has established an advisory committee composed of individuals from industry, academic, and State governments to obtain their input in managing the system.

1. NOAA's Findings. The NOAA policy document submitted to Congress in June 1980 identified some of the expected user needs to be met by an operational system. The agency concluded that the following performance standards were needed for a high quality operational system:

- Sensors designed to generate data meeting a broad range of user requirements at a reasonable price;
- Assured continuity of satellite coverage without break, with one backup satellite in orbit at all times and another on the ground;
- 95% confidence that, averaged over the a two-day period, all data will be processed and made available from the ground station within 48 hours of receipt; and
- Ability to identify and process certain data out of order to meet urgent user needs. 66/

NOAA had conducted a preliminary survey of user requirements for this policy document, which indicated that "agencies interested in renewable resource applications such as agricultural crop assessment want frequent observations, delivery of data within 48 hours in certain circumstances, spectral bands that discriminate between various types of vegetation and resolution higher than that provided by the current Landsat system." Users requiring data for land use management and environmental observations, on the other hand, "request higher resolution over urban and suburban areas and time-series analyses to detect detailed changes." The geological community, especially companies interested in mineral extraction, require "stereoscopic capabilities, global coverage, thirty to forty meter resolution and processing of data within a few weeks." 67/ Table 5 summarizes

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66/ U.S. Department of Commerce. National Ocean and Atmospheric Administration, op. cit., p. 5.

67/ Ibid., p. 6.

TABLE 5

Summary of Possible Requirements for Land Remote Sensing (ALL Domestic Users)
(Based on Available Data as of April 1, 1980)

Performance Parameter	PROGRAMMATIC CATEGORY GROUPS		
	Renewable Resources	Non Renewable Resources	Planning/Environmental Management
Spatial Resolution (Meters)	Range 2-80 m; 10-30 m Most Useful 2-30 m meets 90% of Requirements1/ 10-30 m meets 81% of Requirements 15-30 m meets 80% of Requirements4/ 30-80 m meets 10% of Requirements	Range 3-100 m; 30-80 m Most Useful 3-30 m meets 30% of Requirements 10-30 m meets 28% of Requirements 15-30 m meets 28% of Requirements4/ 30-80 m meets 70% of Requirements	10-80 m; 10-30 m Most Useful 10-30 m meets 60% of Requirements 15-30 m meets 50% of Requirements4/ 30-80 m meets 40% of Requirements
Spectral Bands	MSS/TM Type Plus Microwave	MSS/TM Type Plus Microwave	MSS/TM Type
Timeliness (Observation to User, Days)	2 Days – 15%2/3/ 2-7 Days – 60% 7-30 Days – 35%	30 Days 100%	2-7 Days – 40%2/3/ 7-30 Days – 60%
Repeat Coverage Cycle (Days)	6-7 Days – During Growing Season Seasonal at Other Times3/	Seasonal	Seasonal
Area Coverage	Global Capability	Global Capability	Domestic Capability
Stereo Coverage	Needed for 20% of the Requirements	Needed for 35% of the Requirements	Needed for 15% of the Requirements
Estimated Annual Data Volume (185 KM Square Scenes)	22,000 to 29,000	16,000 to 18,000	4,000 to 6,500

1/ Percentage determined largely from expressed agricultural requirements. Other applications, as they become known, would cause some limited increase.

2/ Very rapid data delivery is required for observations over areas affected by major hurricanes, floods, earthquakes, pollution events, and similar episodes.

3/ Most critical requirements are for data which is used by the government or industry in regional or global crop condition assessment and production forecasting.

4/ Estimate by NOAA based on incomplete information in user requirements data base. Cost and complexity for adding a single channel at 10 m instead of 15 m is under evaluation.

Source: U.S. Department of Commerce. National Oceanic and Atmospheric Administration. Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options. Rockville, Md., NOAA, June 20, 1980. p. 42.

NOAA's findings regarding user requirements in an operational land remote sensing satellite system.

2. Improving Image Resolution. As the NOAA survey indicated, one of the areas which interests users of remote sensing data is the image resolution of the sensors onboard the satellites. The Thematic Mapper on Landsat D and D' will have 30 meter resolution, meaning that it can distinguish objects that are 30 meters in diameter or more. This is the best resolution to date in the Landsat program, although the Earth Resources Experiment Package carried on board Skylab reportedly acquired 35,000 frames of photographs with 17 meter resolution, and some photographs might have had 7 meter resolution. 68/ There are rumors that early photographs taken by the astronauts were of such high resolution that the Department of Defense (DOD) insisted that they be withheld from public release, or that the photographs were purposely blurred to conceal the level of detail that could be discerned from orbit. 69/

Civil users of remote sensing data who wish for better resolution have claimed for years that DOD will not allow civil remote sensing systems to have very high resolution. While this has never been openly acknowledged by the Government, PD-37 included language stating that advances in image resolution would be permitted "when such needs are justified and assessed in relation to civil benefits, national security, and foreign policy." Whatever explicit language was used in PD-37 identifying the level of resolution which the military sector considers acceptable is classified, but since NASA is currently developing advanced sensors with 10 meter resolution, it could be assumed that this meets with DOD approval.

Charges have also been made that the Office of Management and Budget (OMB) has taken actions that limit resolution on civil satellites. One explanation is that OMB is simply attempting to control how much NASA spends on advancing remote sensing technology, while another is that OMB is acting on DOD's behalf by claiming that civilian development of advanced sensors would be a duplication of services. 70/

A related question is the release of military reconnaissance photographs for use by the civil sector. One argument against this action is that the military sensors are quite different from what civilians would want to use -- military sensors are looking for specific man-made objects, while civil sensors are looking for large scale natural features or

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68/ David A. Methisen. The Unfulfilled Promises of Remote Sensing. New Engineer, June/July 1978, p. 20.

69/ Everly Driscoll. The Bureaucratic Odyssey of a Space Mapping Camera. Science News, Nov. 27, 1971, p. 363.

70/ Mathisen, op. cit.

man-made effects on natural resources, such as pollution. According to this point of view, the military reconnaissance photographs and technology would be of little value to civil users. 71/ Not all civil users appear convinced by this argument, since at the end of 1981, attempts were still underway to gain access to the military data.

3. Advanced Sensors. User requirements for the future also include the development of advanced sensors for studying the Earth from space. A number of advancements have been identified over the life of the Landsat program, and some developmental work has been performed by NASA. Budgetary constraints have limited these efforts, however. Three expected advancements are: multilinear arrays, stereo imaging, and a large format camera.

a. Mulilinear Arrays. The next advancement in land remote sensing is the multilinear array (MLA). These devices are available already on the commercial market for uses such as in facsimile reproductions. There are indications that the Soviets have already flown an MLA for remote sensing purposes and Germany has developed an instrument which will fly on the space shuttle in 1983 using this technology. The first free-flyer in the West using this technology will be the French SPOT satellite in 1984.

As described earlier, scanners use mirrors which ocsillate back and forth to produce images, with the individual sensors imaging the surface below sequentially (called "whiskbroom" technology). Thus, each sensor "time shares" one sweep of the scanner, and the amount of time each sensor has for imaging (its "dwell time") is very short. Multilinear arrays on the other hand, have each of their 6,000 sensors simultaneously image the surface below, taking one linear image at a time (termed "pushbroom" technology). Since these sensors take their images at the same time, the dwell time is much longer. For example, according to Ken Ando of NASA, an MLA sensor operating at the same resolution as the thematic mapper (30 meters) would have a 400-fold dwell time advantage. Other advantages of MLA technology include the absence of moving parts during imaging, the ability to operate at variable electronically defined scan rates matched to the ground velocity at various altitudes, and significant growth potential due to its modular nature. 72/ The improvement in the signal-to-noise ratio because of the increased dwell time can be used to obtain higher resolution, perhaps as good as 3 meters, although the current NASA technology development program is officially attempting to attain 10 meter resolution with MLAs. 73/

71/ James Welch, NASA Office of Space and Terrestrial Applications. Private communication, March 1982.

72/ Ken J. Ando. The MLA Program At NASA. Paper presented to the International Geoscience and Remote Sensing Symposium, June 1-4, 1982, Munich, Germany.

73/ Ken J. Ando, NASA Office of Space Science and Applications, private communication, June 1982.

NASA's Goddard Space Flight Center and Jet Propulsion Laboratory are performing R&D on MLA technology at a modest level of funding (a total of approximately $10 million per year). Although NASA does not have an approved program to fly MLA sensors, such an effort may be requested as a new program start in FY84. Initially, the sensors might be flown on the shuttle, with later transition to a free flyer.

(2) Stereo Imaging: Stereosat and Mapsat. One application of MLA technology is stereo imaging, which provides three-dimensional imagery, instead of the two-dimensional imagery available from existing Landsats. Two or more images are taken from different angles, from which the user can infer the relative height of topographic features. This is particularly useful for geological applications, but can also be utilized in other areas of remote sensing analysis.

The French satellite, SPOT will be the first land remote sensing satellite capable of stereo imaging. The United States has considered development of stereo technology for several years, and two programs (Stereosat and Mapsat), were planned, but have not been initiated.

The utility of stereo imaging was identified by the Applications User Working Group for Landsat D in 1976. 74/ Later that year, the Geosat Committee, a group of 100 U.S. and non-U.S. international oil, gas, mineral, and geological engineering companies, also identified the needs for such a capability, and included a proposal, named "Stereosat," in its list of potential space missions which would meet their needs. 75/

In November 1976, NASA's Jet Propulsion Laboratory (JPL) began studying the feasibility of a Stereosat mission using an Applications Explorer spacecraft (for other missions in this series, see section II). Working with the Geosat Committee, JPL defined a satellite, using two cameras oriented 23° fore and aft of the nadir, which would be placed in a sun-synchronous orbit providing a swath width of 30 kilometers and an instantaneous field of view of 16 x 19 meters. JPL and Geosat proposed that this be included as a new start in NASA's FY79 budget.

74/ The history of the Stereosat program is based on: U.S. National Aeronautics and Space Administration. Jet Propulsion Laboratory. Preliminary Stereosat Mission Description. May 30, 1979. Pasadena, California, NASA/JPL, 1979. 720-33. pp. 1-1 and 1-2.

75/ F. B. Henderson, III and G. A. Swann. Geological Remote Sensing from Space; report of the Ad Hoc Geological Committee on Remote Sensing from Space With Recommendations for a GEOSAT Program, Flagstaff, Arizona, May 10-14, 1976. Berkeley, California, Lawrence Berkeley Laboratory, 1976. p. 1-1.

NASA did not request funding for Stereosat because of its expected costs and because it did not want to focus on one specific application of remote sensing technology. 76/ The Geosat Committee lobbied on behalf of the program, and the House Science and Technology Committee provided $4 million in NASA's FY79 budget to begin the program. 77/ Ultimately, only $0.5 million was actually included in the NASA's FY79 budget, and it was for continuing the JPL studies. In authorizing the $0.5 million, Congress encouraged NASA to propose Stereosat as a new program in FY80, but indicated that it wanted private sector financial support for the program. 78/ NASA worked with the Geosat Committee in an attempt to develop sufficient interest among Geosat's members to provide some of the funding, but to no avail. 79/

In the continuation of the studies by JPL, the argument was successfully made by the USGS to add a third nadir-looking camera and to increase the swath width. A revised Stereosat plan was thus developed and issued by NASA/JPL in July 1980. 80/

As finally defined by NASA, Stereosat would have had three cameras, one nadir looking, and two facing fore and aft 23° from the nadir along the spacecraft flight line. Stereo information could be obtained from any pair. The cameras would have used push-broom MLA detectors with 4096 elements. Swath width would have been 61.4 km, and the swaths would have been repeated every 48 days.

Without funding support from the user community, the program has been terminated.

Mapsat has been proposed by the U.S. Geological Survey and would be specifically designed for cartographic purposes. A conceptual design of Mapsat was prepared for USGS by ITEK Optical Systems Division, teamed with TRW's Defense and Space Systems Group, and was released in December 1979 (an addendum was released in February 1980). The satellite technology would have been very similar to Stereosat, and could have provided map scales at 1:50,000, as well as information for oil and gas exploration. The satellite, using three spectral bands (0.47-0.57 microns, 0.57-0.70 microns, and 0.76-1.05 microns), would have had a resolution of 10 meters. 81/

76/ Aviation Week and Space Technology, Feb. 20, 1978, p. 11.

77/ Aerospace Daily, March 1, 1978, p. 1.

78/ Aerospace Daily, November 28, 1978, p. 114.

79/ Ibid.

80/ NASA/JPL, op. cit., p. 1-2.

81/ ITEK Optical Systems Division. Conceptual Design of An Automated Mapping Satellite System (MAPSAT). Technical Proposal. Prepared for U.S. Geological Survey in response to RFP No. 6398. December 17, 1979. (Also: Technical Proposal Addendum, February 13, 1980).

c. Large Format Camera. Apart from multispectral scanners and MLAs, another option in remote sensing is photographic imagery. This has been accomplished on Landsats 1-3 using the Return Beam Vidicon cameras, but no RBVs are included on Landsat D/D'. NASA has developed a Large Format Camera, however, with better resolution (10 meters) than the RBVs which will be flown on the space shuttle as part of the OSTA-3 payload in June 1984. The Large Format Camera will acquire mapping quality photographs with black and white, color, and color infrared film.

The European Space Agency is also planning to fly a Large Format Camera, perhaps with 1 meter resolution, on the space shuttle in 1983 or 1984.

F. Current Status of Private Sector Takeover

At the end of 1981, the future of the U.S. civil land remote sensing satellite program was notably uncertain. The directive from the Carter Administration (PD-54) which transferred responsibility for the operational aspects of the program from NASA to NOAA, with eventual takeover by the private sector, was still being implemented, but the emphasis by the Reagan Administration had changed to transferring the program to the private sector in the short-term, rather than in 7-10 years as envisioned under PD-54.

As summarized previously, COMSAT has proposed that it be made the "designated entity" for operating all U.S. civil remote sensing satellites, including those for meteorological purposes. At the end of 1981, the President's Cabinet Council on Commerce and Trade met to begin considering two questions: the best mechanism for transferring Landsat to the private sector, and if weather satellites should be transferred to the private sector at the same time. The latter question was expected to create some controversy, since civil weather satellites are utilized to some extent by the Department of Defense, and it appeared unlikely that DOD would support transfer of such systems to the private sector. A decision by the Cabinet Council is expected in early 1982.

Other companies rumored to be interested in operating the civil land remote sensing system include: General Electric (which builds the existing Landsat satellites), Hughes Aircraft, Western Union, Lockheed Missiles and Space, TRW, and IBM. 82/ All of these assume Government involvement, direct or indirect.

Terra-Mar Associates has indicated an interest in building and operating a totally private land remote sensing satellite system. According to its president, Don Walklet, the market for remote sensing data is significant and satellites using off the shelf technology could be

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82/ Making Landsat a Private Eye. Business Week, June 30, 1980, p. 49.

launched for one-fifth the NASA cost (using a privately-developed launch vehicle called Percheron). He estimated the cost of 6-10 launches at $40 million. 83/

The American Science and Technology Corporation (ASTECH) has also developed a proposal for private sector operation of remote sensing systems. As described in the joint House/Senate hearings in the summer of 1981, the concept is called FOODSAT/PETROSAT and would utilize several small satellites in sun-synchronous polar orbits. Existing Landsat receiving stations would receive the data. According to its sponsors, the concept would use existing technology and fill the needs of an existing market, and would not require government subsidies (although it would ask for assurances that Government systems would not compete for the same market). This group also plans on utilizing the Percheron launch vehicle for placing its satellites in orbit.

83/ Quoted in: California Company Wants to Market Remote Sensing Service Without Government's Help. Satellite News, Aug. 10, 1981, p. 6. The Percheron launch vehicle is being developed by a company called Space Servicies, Inc. By the end of 1981, one test firing of the rocket had been unsuccessfully attempted; the next is planned for August 1982.

V. INTERNATIONAL ASPECTS OF THE LANDSAT PROGRAM AND SATELLITE REMOTE SENSING

A. International Use of Landsat Data

Throughout the history of the Landsat program, the United States, through NASA, the Department of State, and the Department of Interior, has sought to share remote sensing data with other countries and to train their scientists in using the data for purposes such as land management. In addition, many foreign countries, including the Soviet Union, purchase Landsat data directly from the EROS data center. Several nations have also constructed receiving stations so that they can acquire Landsat data directly from the satellite.

1. U.S. Government Agencies with International Involvement. Three U.S. Government agencies have assisted in providing foreign nations with earth resources remote sensing information. The U.S. Geological Survey (part of the Department of Interior) has sponsored several international remote sensing training programs at the EROS data center and in foreign countries.

The Department of State is primarily responsible for coordinating remote sensing programs to foreign nations to assure consistent development of the international aspects of the Landsat program. In addition, the Agency for International Development (AID) supports and encourages remote sensing activities in less developed countries (LDCs) by providing: U.S experts, training, and demonstrations; project grants; financial and technical support for cooperative programs with U.S. industries and institutions; and financial support for formal education in U.S. universities, on-the-job training, and creation of national and regional remote sensing centers. Centers have been established in Nairobi, Kenya and Ouagadougou, Upper Volta. Another is planned for Bankok. 84/ A summary of the AID program is shown in Table 6.

In addition to the bilateral agreements for Landsat receiving stations (discussed below), NASA encouraged international involvement in Landsat through substantial participation of foreign investigators sponsored and funded by 50 countries and 4 international organizations through 1978 (see table 7). These activities involved utilization of data from

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84/ U.S. National Aeronautics and Space Administration. Office of Space and Terrestrial Applications. Analysis of the Private Market for Landsat Products and Applications: Final Report. Prepared by OAO Corporation. Washington, NASA, March 31, 1981. NASA has abandoned plans for centers in Latin American and the Near East.

TABLE 6

United States Agency for International Development Remote Sensing Program

GRANTS	PROJECTS	CENTERS	TRAINING
Bangladesh: map areas for third rice crop	Costa Rica: forest survey	Regional:	EROS Data Center
Bolivai: explore iron formations	Bolivia: population census	Nairobi, Kenya	South Dakota State Univ
Cameroon: develop resource management techniques	Senegal: resource inventory	Ouagadougou, Upper Volta	Univ. of New Mexico
Chile: inventory resources	Upper Volta, Togo, Benin: Onchocerciasis (river blindness) - free area survey	Planned:	Argentina
Haiti: measure sugar cane	Morocco: geological mapping	Bangkok, Thailand	Peru
Lesotho: investigate snowfall and drainage patterns	Mali: range management	Cairo, Egypt	Botswana
Pakistan: map river sediment loads for new port location	Kenya: population census (land cover & use)	2 planned in Latin America	Senegal
Peru: identify and map aguaje palm	Bangladesh: weather satellite station	National:	Sudan
Phillipines: assist development of Mindoro Island	Dominican Republic, Jamaica, Costa Rica, Ecuador, Bolivia, Morocco, Thailand, Philippines, and Indonesia: agricultural crop estimates	Cairo, Egypt	Nepal
Sri Lanka: measure rice crop		Tunis, Tunisia	
Swaziland: locate ground water		Kinshasa, Zaire	
Thailand: survey agriculture		Bangkok, Thailand	
Zaire: provide map base		Planned:	
		Younde, Cameroon	
		Damascus, Syria	
		Katmandu, Nepal	

Source: U.S. National Aeronautics and Space Administration. Analysis of the Private Market for Landsat Products and Applications: Final Report. Prepared by OAO Corporation in Response to Task Order 25, Contract No. NASW3358. Washington, NASA, March 31, 1981. p. 5-3.

TABLE 7

International Participation in NASA's Earth Resources Investigations Programs*

- Argentina
- Australia
- Bangladesh
- Belgium
- Bolivia
- Botswana
- Brazil
- Canada
- Central Treaty Organization
- Chile
- China
- Colombia
- Commission of European Communities
- Ecuador
- Egypt
- European Space Agency
- Finland
- Food and Agriculture Organization
- France
- Germany, Federal Republic of
- Greece
- Guatemala
- India
- Indonesia
- Iran
- Israel
- Italy
- Japan
- Kenya
- Korea
- Lesotho
- Libya
- Malaysia
- Mali
- Mekong Commission
- Mexico
- Netherlands
- New Zealand
- Norway
- Pakistan
- Peru
- Philippines
- Romania
- South Africa
- Spain
- Sri Lanka
- Sweden
- Switzerland
- Thailand
- Turkey
- United Kingdom
- Venezuela
- Zaire

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* Adapted from: NASA. A Review of NASA International Programs As of January 1, 1982. Appendix B.

Landsat 1 and 2 and the Skylab Earth Resources Experiment Package for 163 investigations which were selected by NASA based on scientific merit. NASA provided the data, while the countries performed the experiments and provided the results to NASA. No exchange of funds was involved.

b. Foreign Landsat Receiving Stations. At the end of 1981, ten ground stations to receive and process Landsat data were in operation outside the United States. These stations are in Argentina, Australia, Brazil, Canada (which has two), India, Italy (owned by the European Space Agency), Japan, South Africa, and Sweden (owned by ESA). A station in Thailand is expected to become operational in early 1982. In addition, China and Indonesia have signed memoranda of understanding (MOUs) with NASA to construct receiving stations, and Kenya, Mexico, Nigeria, Romania and Upper Volta have indicated interest. Three countries (Chile, Iran, and Zaire) had signed MOUs for Landsat receiving stations, but these have lapsed.

The MOUs which are signed in order for a foreign country to gain permission to build a Landsat receiving station stipulate that: (1) none of the costs of the facilities will be borne by the United States; (2) the foreign cooperating agency must provide NASA any and all data desired by NASA (which is of particular importance when the tape recorders on the Landsat satellites fail); (3) the foreign cooperating agency will provide free of charge the data requirements of NASA to selected experimenters, and to the public in the region of its station for reasonable charges; (4) it will pay whatever access fee is required by the United States; and (5) NASA does not guarantee a continuing program.

Inititally, there was no charge to foreign nations for receiving data at their ground stations, but in December 1975, NASA notified nations operating or planing Landsat stations that, as provided in the MOU, they would be assessed an access fee of $200,000 per year for the costs of the space segment of the Landsat program. At the end of 1981, NOAA was considering raising the access fee to $600,000.

3. United Nations Programs. The United Nations has a long history of fostering a climate for international sharing of the benefits from remote sensing data. In 1969, the U.N. Committee on Peaceful Uses of Outer Space (COPUOS) established a Space Applications Program, which has sponsored numerous seminars/training sessions on utilizing remote sensing data. A U.N. Expert on Space Applications has also been designated.

During the 1970's, as the satellite remote sensing program progressed and the utility of its data to countries throughout the world became evident, the role of the United Nations grew. 85/ Two remote sensing centers have

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85/ Information on U.N. satellite remote sensing programs is partially based on: Role of the United Nations System in Space Activities. Background paper prepared for the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space. New York, United Nations, October 21, 1981. A/CONF.101/BP/11/Add.1.

been established, one in the United Nations Center for Natural Resources and Energy Division (CNRED) of the Department of Technical Cooperation for Development (TCD), and the other at the Food and Agriculture Organization (FAO) of the United Nations in Rome. The CNRED/TCD remote sensing unit provides assistance in designing and evaluating remote sensing projects in which satellite data is used, designs programs to integrate remote sensing data into economic development projects, sponsors the establishment and strengthening of training centers, and advises governments interested in using satellite remote sensing data. The FAO unit provides advisory services and technical assistance (including training) to individual countries, provides support to and coordinates activities between FAO headquarters and field programs using satellite remote sensing data, and serves as a liaison between FAO and other organizations concerned with space applications.

A major component of the activities of FAO and CNRED (which are financed through the U.N. Development Program) is providing the equipment necessary to undertake a specific project. Approximately two-thirds of the cost of a project is for equipment.

The U.N. Disaster Relief Oganization (UNDRO) is evaluating the potential of using satellite remote sensing data in disaster relief activities. A draft remote on the potential role of satellites in disaster relief activities is expected to be released in 1982. The U.N. Educational, Scientific, and Cultural Organization (UNESCO), has several projects related to utilization of remote sensing data, including mineral exploration, hydrology, and oceanic research.

The World Bank, a specialized agency of the United Nations, has two sections which utilize remote sensing data: the Resource Planning Unit (RPU) of the Agriculture and Rural Development Department, and the Cartographic Division (CD) of Administrative Services. The RPU uses data in assessing the feasibility of Bank-financed projects; while the CD uses them for producing or updating small-scale maps for Bank reports.

In addition to these specific activities, COPUOS has served as a forum for a long-standing debate over the legal implications of remote sensing, as discussed in section 4.

4. Issues Concerning Utilization of Landsat Data by Developing Countries. Examples of actual programs utilizing satellite remote sensing data have been described at length in other publications, so need not be repeated here (for example, the Scientific and Technical Subcommittee of COPUOS publishes reports each year cataloging remote sensing activities throughout the world). 86/ Instead, this section will focus on issues connected with utilization of remote sensing data by less developed countries (LDCs).

86/ The most recent is: Report of the United Nations Expert on Space Applications to the Scientific and Technical Subcommittee. List of Remote Sensing Applications. New York, United Nations, January 19, 1981. A/AC.105/257/Add.1/Rev.1.

Charles K. Paul, manager of the Remote Sensing Program for the U.S. Agency for International Development, has written extensively on this topic. In a 1981 article, he and Adolfo C. Mascarenhas of the Bureau of Resource Assessment and Land Use Planning at Tanzania's University of Dar es Salaam, identified six major issues of concern to LDCs. Several of these have been discussed elsewhere in this report, but will be included here for completeness. 87/

The first issue concerns the operational land remote sensing satellite system. Not only does this involve the issue of continuity of the U.S. program past Landsat D/D', but also the arrangements which might be made for an operational (as opposed to an experimental) system. Paul and Mascarenhas delineate the following potential problem areas: increase in prices for Landsat data products, increase in access fees, and imposition of a copyright on all data products if the system is operated by the private sector (meaning that a fee would have to be paid each time the data were reproduced).

A second potential problem area is the international debate over the spatial resolution of images. As detailed elsewhere in this report, some countries want to have the right of "prior consent" over who should be able to receive high resolution images of their land and natural resources because of economic and national security concerns. The U.S. policy is to make all satellite remote sensing data available to everyone on a non-discriminatory basis. According to Paul and Mascarenhas, "Some Third World countries, ever vigilant regarding resource mapping along poorly defined frontier, are not satisfied with the present U.S. position." 88/

The disparity between information available to mineral-rich countries and that available to multinational firms using satellite technology is another issue identified by Paul and Mascarenhas. According to their thesis, the ability of the mineral-rich nations to utilize remote sensing data to carry out their own surveys may improve the often difficult negotiations between the countries and multinational companies.

Transfer of computer processing techniques to the LDCs is another problem. 89/ According to Paul and Mascarenhas, "the limitation of digital

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87/ Charles K. Paul and Adolfo C. Mascarenhas. Remote Sensing in Development. Science, October 9, 1981, pp. 139-145.

88/ Ibid., p. 144.

89/ See also: Charles K. Paul. Transfer of Remote Sensing Computer Technology to the Developing World - Case Examples. Paper Presented to the 1979 Machine Processing of Remotely Sensed Data Symposium. June 27-29, 1979.

image technology to spectral information and the difficulty of learning to use and maintain equipment associated with the technology" have been the primary difficulties encountered in attempts to transfer the technology. The training programs previously described will assist experts from the LDCs in learning how to use the digital system technology.

The last two issues discussed by Paul and Mascarenhas concern the desire of many foreign countries to achieve autonomy in remote sensing data by either (1) building their own receiving stations, or (2) building their own satellites. These are discussed in the next section.

B. Remote Sensing Satellite Systems in Other Countries

As noted above, some foreign countries have decided to develop their own remote sensing satellite system. Five countries and one international organization are actively purusing earth remote sensing satellites: the European Space Agency, France, Germany, India, Japan, and the Soviet Union.

1. The European Space Agency. The European Space Agency (ESA) is a group of 11 member countries which was established in 1975. 90/ In the area of satellite remote sensing, ESA decided in 1981 to propose development of the Earth Resources Satellite 1 (ERS-1) to be launched in 1987. The 2.2 ton satellite will be used primarily for ocean sensing, and its primary instrument is planned to be a synthetic aperature radar. Under current plans, it will also carry an ocean color monitor, and a radar altimeter for measuring wave height to within 5 centimeters. ERS-1 is an experimental system, which may be the basis for a multi-satellite operational system sometime in the 1990's.

2. France. In February 1978, France decided to develop the SPOT satellite which will be launched in 1984. (Belgium and Sweden are also participating in the program.) This will be the first satellite capable of stereo imaging, and will use pushbroom multi-linear array technology. The satellite will carry two identical high resolution visible (HRV) instruments with 20 meter resolution in the multispectral mode, and 10 meter resolution in the panchromatic (black and white) mode. 91/ The

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90/ The members of ESA are: Belgium, Denmark, France, Federal Republic of Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. Austria and Norway are associate members, and ESA has a technical agreement of cooperation with Canada.

91/ Satellite-Based Remote Sensing System. Centre National d'etudes Spatiales. Toulouse, France. [n.p.,n.d.]

multispectral instrument will use the green, red, and near-infrared bands. Each instrument will have a ground swath of 60 kilometers, and can be independently pointed either along the vertical or at an angle within ± 27° to the East or West of the orbital plane. The instruments can be pointed so as to cover adjacent fields, providing a swath width of 117 kilometers.

Weighing 1,750 kilograms at launch, the satellite will be placed in a near polar, sun-synchronous (98.7°) orbit at 832 kilometers, with a 10:30 a.m. equatorial crossing. Although the orbit will repeat itself only once every 26 days, the pointing capability of the instruments will allow imagery from each area to be gathered every 4 days at the equator, and 2.5 days at 45° latitude.

The data will be transmitted to the ground at 50 megabits per second, and SPOT will have two on-board tape recorders for storing data for later transmission to the central receiving station near Toulouse, France. It is expected that Landsat receiving stations can be modified for a relatively low cost to receive SPOT data as well.

The stereo imaging capability of SPOT, while it will be the only one available for some time, has been criticized because it takes images on successive orbital passes, rather than simultaneously, as would have been possible with a system such as Stereosat.

Because of the high resolution on the panchromatic band (10 meters), France may distribute data from that band only with the permission of the sensed country, 92/ although by the end of 1981, a final decision had not been made by the French government. A company called Spot-Image is being established to market and distribute SPOT data and will have French, Belgian and Swdeish stockholders. The French space agency, CNES, will have a 36% share in the company.

3. Germany. Germany is developing a remote sensing instrument that will be flown on the space shuttle in 1983. Called MOMS, for Multispectral Optical Modular Scanner, it will use pushbroom multi-linear array technology. MOMS will fly as part of Germany's first Shuttle Pallet Satellite (SPAS-01) payload, and is expected to have 30-50 meter resolution in visible bands, and 100 meter resolution in the infrared. It will be capable of changing swath width between 55, 110, and 240 kilometers, depending on desired resolution. 93/

92/ Charles K. Paul and Adolfo C. Mascarenhas, op. cit., p. 145.

93/ Craig Covault. Germans Develop Multimission Satellite. Aviation Week and Space Technology, May 8, 1978, p. 55.

4. India. The first Indian remote sensing satellite was launched by the Soviet Union in 1979. Named Bhaskara I (or SEO I) it carries two microwave radiometers and a television camera for observations in the visible and near infrared bands. Electrical arcing in the television camera power system led Indian engineers to decide not to activate that system, 94/ but both radiometers functioned properly. The satellite was turned off in May 1981. 95/

Bhaskara II (SEO II), another earth resources satellite, was launched for India by the Soviets in November 1981. The satellite carries instruments similar to Bhaskara I.

India is planning a series of advanced remote sensing satellites for the 1980's. Called Indian Remote Sensing (IRS) satellites, the first will carry three Linear Imaging Scanning Sensor (LISS) cameras. Image resolution will be 70 meters with a swath width of 140 kilometers, or 40 meters with a swath width of 180 kilometers. 96/

5. Japan. At the present time, Japan is planning two remote sensing satellites. The first, MOS-1 (Marine Observation Satellite) is expected to be launched in 1986 97/ for observing the ocean. The second, ERS-1 (not to be confused with the ESA satellite with the same designation), will be launched two years later and will focus on oil and mineral exploration.

MOS-1 will weigh 750 kilograms, and will be placed in a 909 kilometer sun-synchronous orbit. The satellite will carry four instruments, including a multispectral electronic self scanning radiometer. This instrument will operate in four bands (0.51-0.59 microns; 0.61-0.69 microns; 0.72-0.8. microns; and 0.80-1.1 microns) for providing data on sea-surface color and will have a resolution of 50 meters. The other instruments are a microwave scanning radiometer (for measuring the water content of the atmosphere), a visible and thermal-infrared radiometer (for sea-surface temperature), and a data collection system. 98/

94/ David Velupallai. ISRO: India's Ambitious Space Agency. Flight International, June 28, 1980, p. 1466.

95/ Government of India. Department of Space. Annual Report 1981-82. Bangalore, India, 1982. p. 4.

96/ Ibid., p. 14.

97/ Launch was originally planned for 1984, but has been slipped to 1986.

98/ National Space Development Agency of Japan. Marine Observation Satellite-1, (MOS-1). September 1980.

ERS-1 is scheduled to carry a synthetic aperture radar capable of 20 meter resolution, a stereo camera, and visible/infrared measurement systems. 99/ The satellite will be the heaviest launched by the Japanese, weighing 1,215 kilograms. Japanese oil, metals, and electronics companies, in cooperation with the Ministry of International Trade and Industry, are establising an earth resources observation analysis center in connection with the planned ERS-1 program to enhance Japan's computer technology for utilizing spacecraft data for resources monitoring. 100/

An Earth Observation Center (EOC) already has been established in Japan for using Landsat data. When Japan begins launching its own satellites, the center will be used as a mission control center, and the receiving/processing center.

6. Soviet Union. Like the United States, the first earth resources observation data collected by the Soviets was accomplished using manned vehicles, beginning with Soyuz 9 in 1970. Today, remote sensing instruments are flown as part of the Kosmos program, the Meteor weather program, and the manned space station program.

Beginning in 1979, the Soviets began launching satellites in the general Kosmos series which are indistinguishable from military reconnaissance satellites in terms of their orbital characteristics and telemetry. Launched into 82.3° inclination orbits, the TASS announcement accompanying these launches identifies the payload as having an earth resources purpose. No further information is available on what type of data is received.

The Meteor program has been used to fly sensors for land and ocean remote sensing since approximately 1978. Satellites launched in the Meteor 2 series have been identified as carrying new remote sensing sensors. Information on the components and characteristcs of Meteor-2 vehicles is shown in Table 8.

In June 1980, the Soviets launched a Meteor satellite which carried a 600 kilogram experimental sensor system including several different scanning devices: a multispectral mechanical scanning device with medium resolution (MSR-RA), a multispectral electronic scanning device with high resolution (MSU-VA), and a multispectral system designated Fragment 2.

99/ Japanese Gain Capabilities in Advanced Space Effort. Aviation Week and Space Technology, March 9, 1981, p. 107.

100/ Aviation Week and Space Technology, August 17, 1981, p. 15.

TABLE 8

Equipment Components and Characteristics of On-Board Information Complex of "Meteor-2" Vehicle

Equipment	Spectral Bands (Microns)	Coverage (kilometers)	Resolution (kilometers)
Scanning telephotometer for direct imaging	0.5 - 0.7	2100	2
Scanning telephotometer for global coverage	0.5 - 0.7	2400	1
Scanning IR-radiometer for global coverage	8-12	2600	8
Scanning IR-spectrometer	8 channels in bands of 11,10-18, 70	1000	30

Source: Union of Soviet Socialist Republics. National Paper: USSR. Prepared for Second United Nations Conference on Exploration and Peaceful Uses of Outer Space. New York, United Nations, September 2, 1981. A/CONF.101/NP/30. p. 23.

These instruments are prototypes for later use on a continuously operating quick-look subsystem for observing characteristics of rapidly-varying changes in the natural environment. 101/ The characteristics of these systems are shown in table 9.

A new class of satellites, designated Meteor-Priroda, appeared in 1981. Priroda is the Russian word for nature, and is the name of the central earth remote sensing facility in the Soviet Union. The Meteor-Priroda spacecraft is three-axis stabilized, and placed into a sun-synchronous orbit at 600-650 kilometers. Usually, the satellites carry two multi-spectral television-type devices, designated MRTVK. One operates in four spectral bands (0.5 to 0.6 microns; 0.6 to 0.7 microns; 0.7 to 0.8 microns; and 0.8 to 1.1 microns) with 1,930 kilometer coverage and 1 x 1.7 kilometer resolution. The other operates in two bands (0.5 to 0.7 microns, and 0.7 to 1.1 microns) with 1,380 kilometer coverage and 240 meter resolution. 102/

Remote sensing observations have also been carried out using equipment on the Salyut 1, 4 and 5 space stations, but the most extensive surveys have been conducted using the MKF-6 multispectral camera on board the Salyut 6 space station, which was launched in 1977 and was still functioning at the end of 1981. The MKF-6, with 6 spectral bands (0.46 - 0.50 microns, 0.52 - 0.56 microns, 0.58 - 0.62 microns, 0.64 - 0.68 microns, 0.70 - 0.74 microns, and 0.78 - 0.86 microns) is built by East Germany, and was flight-tested on the Soyuz 22 mission in 1976. It has been reported that on Salyut 6 the instrument provides data with 20 meter resolution, 103/ but that when it was flown on Soyuz 22, permitted 10 meter resolution. 104/ The MKF-6 permits 60% overlap of adjacent areas, and thus provides stereo images.

Salyut 6 also has a topographical camera designated KATE-140 which is used for contour maps. Other cameras may also be used for remote sensing and/or reconnaissance.

Two specialized interdepartmental centers have been established for receiving and processing remote sensing data: the State Scientific-Research Center for the Study of Natural Resources of the State Committee of

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101/ Ibid., pp. 18-19.

102/ Union of Soviet Socialist Republics. National Paper: USSR. Paper Prepared for the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space. New York, United Nations, September 2, 1981. A/CONF. 101/NP/30. p. 24.

103/ Theo Pirard. Salyut 6 Space Station: Three Years in Orbit and Still Operational. Space Age Review, September-October, 1980, p. 3.

104/ Aviation Week and Space Technology, January 2, 1978, p. 11.

TABLE 9

Main Characteristics of MSU-SA, MSU-VA Devices and "Fragment-2" System

Equipment	Spectral Band (Microns)	Coverage (kilometers)	Field, diaphragm projection on the earth surface at nadir (meters)
Multispectral scanning equipment with mechanical scan MSU-SA	1.5 - 0.6 0.6 - 0.7 0.7 - 0.8 0.8 - 1.0	600	170
Multispectral equipment with electronic scanning, MSU-VA	0.5 - 0.7 0.7 - 0.8 0.8 - 1.0	30	30
Multispectral scanning system Fragment 2	0.4 - 0.8 0.5 - 0.6 0.6 - 0.7 0.7 - 0.8 0.7 - 1.1 1.2 - 1.3 1.5 - 1.8 2.1 - 2.4	85	80

Source: Union of Soviet Socialist Republics. National Paper: USSR. Prepared for the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space. New York, United Nations, September 2, 1981. A/CONF.101/NP/30

Hydrometeorology and Environmental Protection, and the State Scientific-Research and Production Center "Priroda" of the Chief Administration of Geodesy and Cartography of the Council of Ministers of the U.S.S.R. The Soviet Academy of Sciences and the Academies of Sciences of the Soviet Socialist Republics carry out research programs connected with utilizing the data.

The Soviets also have a program for remote sensing of the ocean. Experiments on Meteor satellites and manned flights have reportedly been used for this purpose, along with the land remote sensing experiments. In addition, the Soviets have launched a few Kosmos satellites with ocean resources missions. The first to be clearly identified by the Soviets as having this purpose was Kosmos 1076, launched in February 1979, and it was announced that the spacecraft carried two telescopes aimed at the ocean. In January 1980, a second oceanographic mission was launched (Kosmos 1151) and during 1981, two missions with similar orbital characteristics were placed in orbit, although they were not officially identified as being related to ocean resources sensing (Kosmos 1300 and 1328).

C. Proposals to Establish an International Satellite Remote Sensing System

With the growing number of remote sensing systems in development by various countries, several issues have arisen concerning methods of making the systems compatible, or possibly combining them into an internationally operated system. In some cases, the discussion concerns operation of the space and ground segments by an international body, while in others, the space segment would remain under national control, but data dissemination would be primarily effected by the international organization. 105/ In hearings before the House Science and Technology Committee in 1978, for example, Klaus Heiss proposed creation of a Global Resources Information Center to assure the nondiscriminatory access by all nations to civil space observations by the United States, in conjuction with other nations. 106/

Steps have already been taken to increase the compatibility of remote sensing satellite systems. The United States and France, for example, have

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105/ Various options for etablishing a global satellite observation system are examined in: Valerie Hood, Mary E. Kimball, and David A. Kay. A Global Satellite Observation System for Earth Resources: Problems and Prospects: a report to the National Science Founation on the Application of International Regulatory Techniques to Scientific/Technical Problems. St. Paul, West Publishing Co., 1977.

106/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Space Science and Applications. Panel Discussions on International Space Activities. Hearings. 95th Congress, 2d session, June 20, 21, 1978. Washington, U.S. Govt. Print. Off., 1978. p. 141.

worked together to ensure maximum compatibility between Landsat and SPOT, so that data from either series of satellites can can be acquired by the same equipment.

1. Increasing the Role of the United Nations. As described previously, the United Nations has had a steadily increasing role in remote sensing, and it has been suggested that its activities grow even further. The United Nations could operate its own remote sensing satellites and distribute the data under whatever terms the U.N. could agree upon. If the U.N. were to operate both the ground and space segments, the cooperation of technically advanced countries would be necessary, both in terms of technical expertise and funding.

Alternatively, since purchase and operation of satellites is expensive, the U.N. could ask to receive data from satellites operated by other countries, and serve as a data dissemination point only.

The feasibility of a U.N. Data Dissemination Center has been studied by COPUOS. A 1976 report concluded that:

> An international centre could perform a substantial role in several areas. It could provide satellite remote sensing data, equipment and expertise for training courses . . . taking as its point of reference the effective application of all forms of remote sensing to particular natural resource development topics. It could . . . contribute in an important way to the rendering of technical advisory services to Governments in establishing infrastructure and in the promotion of regional use of receiving stations but its most important role would be in encouraging the effective use of satellite remote sensing as another powerful tool in natural resources development and management. 107/

According to the report, the center would have four main functions: (1) to catalog, store, and interpret remote sensing data, providing facilities for examination by interested parties; (2) to circulate available information and to direct requests by countries for remote sensing data to proper sources; (3) to provide impartial advice and assistance to technical assistance projects, member States and United Nations bodies; and (4) to organize specialized training courses for users, managers, and decisionmakers. 108/

107/ Feasibility Study on a Possible Co-ordinating Function for the United Nations in Future Operational Activites in Remote Sensing from Satellites: Revised Concept. Prepared by the Secretariat for the Scientific and Technical Subcommittee of the Committee on Peaceful Uses of Outer Space. New York, United Nations, October 15, 1976. A/AC.105/154/Add.1. p. 7.

108/ Ibid., p. 8.

2. U.N. Affiliate Organization. Instead of having remote sensing systems (space and/or ground segments) operated by the U.N. itself, it might be possible to establish an affiliate organization similar to the World Meteorological Organization. The development of the global meteorological satellite system in existence today is based on satellites that are paid for entirely by the launching country and inexpensive ground stations that are paid for by the user nation. Presumably, a U.N. affiliate operational satellite program for land remote sensing would also rely on the effort of member States to develop and operate the global system, while its role would be coordination and setting policy and standards guidelines. Such an arrangement would relieve the U.N. of the heavy financial burden implicit in owning and operating any part of the system. Again, however, policies such as access to remote sensing data would be set by the U.N., not by individual countries such as the United States.

3. New International Organization. An international system for remote sensing could be patterned after INTELSAT or INMARSAT (see Chapter Three). Like INTELSAT, such an organization could be created as an administrative body including an assembly in which all members would be represented; an executive council, having as permanent members those nations with the largest investment shares in the space segment as well as a number of members elected for a three year period to represent regional global interests; and a permanent staff under the direction of a Secretary-General. Actual management could be entrusted to a corporation. Both the corporation and the organization could be financed in a mutually agreed upon manner by the member countries.

One problem with this scenario is that the economic potential of remote sensing data has not been proven yet. When INTELSAT was established, it was clear that the market potential for transoceanic communications was sufficient to pay for the cost of the system. While there appears to be evidence that benefits from remote sensing outweigh the costs, all experiments in this field have been heavily subsidized. In addition, the major customers for Landsat data are governments rather than individuals, companies, or agencies (who are the customers for communications services). Thus it remains unclear as to whether the technology can pay for itself, and it may therefore be difficult to establish a self-sustaining operational international commercial land remote sensing satellite system.

4. Potential Problems with International Operation. If land remote sensing systems are turned over to an international body for operation, several issues will have to be resolved.

The first of these will be policy regarding distribution of high resolution data. This debate is discussed further in the next section. Almost assuredly, however, the United States would have to accept a compromise to its policy of open dissemination to everyone.

A second potential problem is that an individual country like the United States might lose some degree of political and technical control over the system. For example, although international participation has been an important part of the Landsat program, the United States developed the system primarily for domestic use, and technical and policy considerations based on U.S. policy. In an international scheme, however, other member countries will undoubtedly want to participate in the process of deciding how satellites should be designed, when and where they should be deployed, what kinds of equipment they should carry, and what functions they should perform. Such international participation could compromise the domestic services rendered to American users.

An illustration of this issue can be taken from experience in the development of the meteorological satellite program. When the United States substituted scanning radiometers for video cameras on its weather satellites, a number of countries complained because information extraction was easier with the camera than with the radiometer. The radiometer yielded more valuable data, however, which is why the United States wanted to change instruments. The United States decided to proceed with the radiometer despite international objections, and the utility of the radiometer has proven itself over the years. If the choice had been made by consensus of the international organization, however, technical conservatism may have prevailed. 109/

International management may also prolong the decisionmaking process, which could slow the pace of technological development and innovation. Another risk is politicization in that a group of nations may seek to bar another nation from participating in the benefits of an internationalized system for purely political reasons.

D. International Legal Problems Associated with Satellite Remote Sensing

For the past decade, the United Nations has served as the focal point for the debate over international legal issues associated with satellite remote sensing systems. The primary focus of the debate is over who should have access to the data generated by satellite systems, and has become increasingly controversial as the resolution of the satellite sensors has increased. 110/

109/ R. M. White. The Environmental Satellite: What It Means for Man. Administrator, National Oceanic and Atmospheric Administration, in: The Impact of Space Science on Mankind, Nobel Symposium. New York, Plenum Press, 1976.

110/ For a full discussion of these issues see: Nicolas Mateesco Matte and Hamilton DeSaussure. Legal Implications of Remote Sensing From Outer Space. Holland, A.W. Sijthoff-Leyden, 1976. 197 pp.

1. Earth Resources Versus Meteorological Data. Although many comparisons have been made between meteorological and earth resources satellites, an examination of the different potential uses of the data from each will reveal why the dissemination of earth resources data has generated such intense controversy while distribution of weather information has remained apolitical.

For many years, weather information has been viewed as a truly international concern. Since weather patterns do not respect State boundaries, the exchange of meteorological data has long been considered vital for the protection of life and property. Thus, the creation of the first operational weather satellite system encountered virtually no political resistance.

In contrast, the establishment of earth remote sensing satellites has triggered a great international poltical debate. The controversy concerns the nature and uses of satellite data. While meterological satellites monitor global atmospheric phenomena, the target of earth resources satellite imagery is soverign teritories, and whereas meteorological information may be vital for timely flood and storm warnings, earth resources data can have longer range and strategic political and economic significance. Some nations, therefore, fear that other nations will use earth resources data for purposes of economic exploitation. Specifically, they are concerned that foreign governments, companies or individuals with superior satellite technology (either in terms of the capability of the satellite system itself or data processing capability in analyzing the data provided by the satellite), might be able to learn more about the resources of a country than can the government and people of that country.

2. Image Resolution and Prior Consent. As noted previously, the best resolution available with unmanned satellites today is 40 meters (using the Landsat 3 return beam vidicon cameras), but this will improve to 10 meters when SPOT is launched in 1984. Manned systems on Skylab and Salyut have returned data with resolution of 10 meters or less. Although no information is available in the open literature on the resolution of military satellites, it is thought to be less than one meter, and as the resolution of civil remote sensing satellites approaches that capability, governments are increasingly concerned about purposes for which the data could be used. Thus, some countries want the right of "prior consent" over who should be given access to data about their national resources.

As discussed earlier, U.S. policy regarding dissimenation of data is the open skies policy (everyone has equal access to the data), while France has announced that may follow the principle of prior consent for dissemination of data with 10 meter resolution (but not the 20 meter resolution from its multispectral instrument).

The Soviet Union prepared a treaty, which has been signed by itself and other Soviet bloc countries, called the Convention on the Transfer and Use of Data of the Remote Sensing of the Earth From Outer Space. Article IV states:

> A Contracting Party in possession of initial data of the remote sensing of the Earth from outer space, with a better than 50 meters resolution on the terrain, relating to the territory of another Contracting Party, shall not disclose or make them available to anyone except with an explicit consent thereto of the Contracting Party to which the sensed territories belong, nor shall it use them or any other data in any way to the detriment of the Contracting Party. 111/

It should be noted, however, that the 50 meter resolution stated in the convention refers to photographic resolution, which is roughly equivalent to 20 meter resolution using scanners.

3. National Sovereignty Issues. The concerns about potential economic exploitation and mis-use of satellite data have raised the issue of national sovereignty. One of the basic principles of international law is that each nation holds sovereign rights to natural resources, including the right to dispose of any data concerning these resources. Efforts to protect this sovereignty resulted in the claim that remote sensing was an "earth-oriented" activitity and therefore the principle of the freedom of space, embodied in the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, was not applicable. Consequently, new regulations to govern remote sensing would have to be formulated.

One such suggestion on governing the new technology included the imposition of technical requirements which would allow ground personnel to turn off the satellite sensors over selected areas of the Earth coinciding with natural boundaries. Another required prior consent of the sensed nation before imagery could be gathered by the launcher nation. Thus, initial efforts to protect national sovereignty centered on the prevention or restriction of the space activity itself.

However, it soon became apparent that technical and legal restrictions were neither feasible nor desirable, and that without solving the problem of protecting the sovereign right of states to all data pertaining to

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111/ Signed in Moscow on May 19, 1978 by Cuba, Czechoslovakia, the German Democratic Republic, Hungary, Mongolia, Poland, Romania, and the Soviet Union. Reprinted in: U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Space Law: Selected Basic Documents, Second Edition. Committee Print. Washington, U.S. Govt. Print. Off., December 1978. pp. 489-492.

their natural resources, such restrictions could interfere with international cooperation in studies of the Earth's atmosphere and oceans, in which all states have a vital interest.

Discussion then focussed on that aspect of the system considered to pose the greatest threat to national sovereignty -- dissemination of the data. A consensus was reached that the space segment could be treated separately from the ground segment, and it was generally agreed that the space segment could be conducted in accordance with the freedom of exploration and use principle in the 1967 Outer Space Treaty, but the ground segment would not be covered by the Treaty. According to this view, the ground segment would be governed only by the rules of national sovereignty. Since the free and unrestricted dissemination of data, in this perspective, is not compatible with protection of national sovereignty, any space data dissemination scheme would have to be regulated to protect the sovereign right of a state over information on its natural resources, as well as the resources themselves.

In essence, data gathering was distinguished from its use. Proponents of this approach claim that treating the space and ground segments separately does not raise obstacles for the further development of the practical application of space technology, while it does allow for international regulation to prevent the misue of data collected from space.

4. U.N. Efforts to Establish Principles for Remote Sensing Programs. The United Nations has been actively debating the legal implications of remote sensing since January 1973, when a working group established by the Scientific and Technical Subcommittee of COPUOS first addressed these issues at length. 112/ The subcommittee requested the views of COPUOS' Legal Subcommittee, which also began addressing these issues in 1973. Both subcommittees have worked on developing principles for operation of satellite remote sensing systems since that time.

During the 1973-74 time period, the Soviet Union, Canada, Argentina, Brazil, and France submitted proposals for formulating legal principles for remote sensing to the Legal Subcommittee. By 1975, it had become apparent that the legal issues involved in remote sensing were of increasing concern to COPUOS members, and the Legal Subcommittee allocated one week of its meeting to this subject. A working group was established within the subcommittee. The individual proposals developed earlier were, in some cases, combined, and the working group turned its attention to the three

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112/ This history of COPUOS' debate over remote sensing is partially based on: Gerald J. Mossinghoff and Laura D. Fuqua. United Nations Principles on Remote Sensing: Report on Developments 1970-1980. Journal of Space Law, Fall 1980, p.105.

major proposals: a joint French/Soviet proposal; a joint Argentine/Brazilian proposal; and a proposal by the United States.

Since 1975, this topic has been a priority item on the agenda of the Legal Subcommittee every year, focussing on the development of draft principles. Five draft principles were developed in 1976, but by 1978 this had grown to seventeen. 113/

During its 1977 meeting, the Scientific and Technical Subcommittee made several recommendations concerning remote sensing, including the refinement of definitions, particularly of the terms "data" and "information" as they relate to remote sensing satellite systems. "Data" was redesignated "primary data" and defined to denote the raw data acquired from the satellite, and the pre-processed products derived from those data. "Information" was changed to "analyzed information" and was defined to mean the end-product resulting from the process of analysis performed on primary data, combined with data and knowledge obtained from sources other than remote sensing satellites.

At the same meeting, the Soviet Union submitted a proposal to classify remote sensing data on the basis of spatial resolution: "global" data would include data with resolution of several hundred meters to several kilometers and covering distances from several hundred kilometers to 2,000-3,000 kilometers; "regional" data would have a resolution of 50-100 to 300-500 meters and covering a distance of from 180-200 to 600-800 kilometers; and "local" data would have a resolution from several meters to 30-50 meters and cover a distance of less than 150-180 kilometers. The subcommittee could not agree whether or not it was necessary to classify the data in this manner, and COPUOS recommended that an attempt be made to provide a techincal definition of spatial resolution and determine what aspects of data (resolution, spectral characteristics, etc.) might correspond to particular applications.

The COPUOS Secretariat, together with the Committee on Space Research (COSPAR) of the International Council of Scientific Unions, prepared such a report, which was considered at the 1978 meeting of the Scientific and Technical Subcommittee. The Subcommittee still could not agree on the need for such classifications, but noted that some governments wanted to develop different methods of distributing data based on their spatial resolution. The Soviet Union, for example, suggested that data with better than 50 meter resolution not be disseminated without permission

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113/ The various proposals and draft principles are reprinted in Mossinghoff and Fuqua, Ibid.

of the sensed State because it might affect the economic and/or defense interests of the country. 114/

During 1978, the Legal Subcommittee adopted use of the defintions of "primary data" and "analyzed information" which had been developed by the Scientific and Technical Subcommittee, as well as a new definition of the "remote sensing of the Earth", but noted that no final agreement had been reached on the use of these definitions. They were added as a new draft principle, though.

A number of other new draft principles were also added during the 1978 meeting, bringing the total to seventeen. These continue to form the basis of discussions within COPUOS at the end of 1981, and are as follows (words in brackets indicate that agreement has not been reached on the wording; footnotes similarly indicate areas in disagreement).

Principle 1 115/

For the purpose of these principles with respect to remote sensing of the natural resources of the earth and its environment: 116/

(a) The term "remote sensing of the earth" means "remote sensing of the natural resources of the earth and its environment." 117/

(b) The term "primary data" means those primary data which are acquired by satellite-borne remote sensors and transmitted from a satellite either by telemetry in the form of electromagnetic signals or physically in any form such as photographic film or magnetic tape, as well as preprocessed products derived from those data which may be used for later analysis.

114/ As noted previously, the Soviet Union and other Soviet bloc nations have signed a treaty stating that data with better than 50 meter resolution will not be distributed without prior consent of the sensed country.

115/ The question of the application of these principles to international intergovernmental organizations will be considered later.

116/ The formulation "with respect to remote sensing of the natural resources of the earth and its environment" will be reviewed in light of the title to be given to the principles.

117/ This term is still subject to further discussion. In the view of some delegations, it would be necessary in the future work to further define the meaning of the words "remote sensing of the earth and its environment."

(c) The term "analyzed information" 118/ means the end-product resulting from the analytical process performed on the primary data as defined in paragraph (b) above combined with data and/or knowledge obtained from sources other than satellite-borne remote sensors.

Principle II

Remote sensing of the earth from outer space and international co-operation in that field [shall] [should] be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and taking into consideration, in international co-operation, the particular needs of the developing countries.

Principle III

Remote sensing of the earth from outer space [shall] [should] be conducted in accordance with international law, including the Charter of the United Nations and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, and the relevant instruments of ITU.

Principle IV

1. States carrying out programmes for remote sensing of the earth from outer space [should] [shall] promote international co-operation in these programmes. To this end, sensing States [should] [shall] make available to other States opportunities for participation in these programmes. Such participation should be based in each case on equitable and mutually acceptable terms due regard being paid to principles . . .

2. In order to maximize the availability of benefits from such remote sensing data, States are encouraged to consider agreements for the establishment of shared regional facilities.

Principle V

Remote sensing of the earth from outer space [should] [shall] promote the protection of the natural environment of the earth. To this end States participating in remote sensing [should] [shall] identify and make available information useful for the prevention of phenomena detrimental to the natural environment of the earth.

118/ The content, definition and necessity of the term "analyzed information" is still to be clarified.

Principle VI

States participating in remote sensing of the earth from outer space [should] [shall] make available technical assistance to other interested States on mutually agreed terms.

Principle VII

1. The United Nations and the relevant agencies within the United Nations system should promote international co-operation, including technical assistance, and play a role of co-ordination in the area of remote sensing of the earth.

2. States conducting activities in the field of remote sensing of the earth [shall] [should] notify the Secretary-General thereof, in compliance with article XI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other celestial Bodies.

Principle VIII

Remote sensing of the earth from outer space should promote the protection of mankind from natural disaster. 119/ To this end, States which have identified primary data from remote sensing of the earth and/or analyzed information in their possession which would be useful in helping to alert States to impending natural disasters, or in assisting States to deal with natural disasters should, as promptly as possible, notify those States affected or likely to be affected of the existence and availability of such data and/or information. Such data and/or information should, upon request, be disseminated as promptly as possible.

Principle IX 120/

Taking into account the principles II and III above, remote sensing data or information derived therefrom [shall] [should] be used by States in a manner compatible with the legitimate rights and interests of other States. 121/ 122/

119/ The meaning of this term is subject to further discussion.

120/ Should be considered in connexion with the formulation of a principle on dissemination of data or information and subject to later discussion of the terms "information" and "data."

121/ Some delegations were of the view that, for the sake of consistency it was necessary to consider this principle in light of draft principles II and III.

122/ A delegation reserved its position on removing the square brackets around the words "in a manner compatible with" and on the deletion of the words "not" and "to the detriment of."

Principle X

States participating in remote sensing of the earth either directly or through relevant international organization [shall] [should] be prepared to make available to the United Nations and other interested States, particularly the developing countries, upon their request, any relevant technical information involving possible operational systems which they are free to disclose.

Principle XI

[States [shall] [should] bear international responsibility for [national] activities of remote sensing of the earth [irrespective of whether] [where] such activities are carried out by governmental [or non-governmental] entities, and [shall] [should] [guarantee that such activities will] comply with the provisions of these principles.]

Principle XII

A sensed State [shall] [should] have timely and non-discriminatory access to primary data obtained by remote sensing of the earth from outer space, concerning its territory, on [agreed] reasonable terms and [no later than] [before] access is granted to any third State. 123/ 124/ [[To the greatest extent feasible and practicable,] this principle shall also apply to analyzed information.]

Principle XIII

[A State [intending to conduct] [conducting] remote sensing activities of the earth from outer space shall notify the Secretary-General of the United Nations and [upon request] the States whose territory is intended to be covered by such activities [to the fullest extent feasible and as soon as practicable] of the intended launch, [nature of the] mission, duration and coverage of such activities. The Secretary-General shall publish information thus received.]

Principle XIV

[A State carrying out remote sensing of the earth [shall] [should] without delay consult with a State whose territory is sensed upon request of the latter in regard to such activity, [in particular dissemination of data and information,] in order to promote international co-operation, friendly relations among States and to enhance the mutual benefits to be derived from this activity.]

123/ The question of from which States access to and provision of data should be obtained, needs further consideration.

124/ Subject to review in light of the discussion on access by third States.

Principle XV

[States carrying out remote sensing of the earth shall not, without the approval of the States whose territories are affected by these activities, disseminate or dispose of any data or information on the natural resources of these States to third States, international organizations, public or private entities.]

Principle XVI

[Without prejudice to the principle of the freedom of exploration and use of outer space, as set forth in article I of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, remote sensing of the earth [should] [shall] be conducted with respect for the principle of full and permanent sovereignty of all States and peoples over their own wealth and natural resources (with due regard to the rights and interest of other States and their natural and juridical persons in accordance with international law] [as well as their inalienable right to dispose of their natural resources] [and of information concerning those resources.]]

Principle XVII

[Any dispute that may arise with respect to the application of [Activities covered by] these principles [shall] [should] be resolved by prompt consultations among the parties to the dispute. Where a mutually acceptable solution cannot be found by such consultations it [shall] [should] be sought through other [established] [existing] procedures for the peaceful means of settlement of disputes mutually agreed upon by the parties concerned.] 125/

By the end of 1981, no further progress had been made on reaching agreement on these principles at the United Nations.

125/ Subject to review in the light of the fulls set of agreed principles and a decision on the legal nature of the principles.

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WEATHER SATELLITES: AN OVERVIEW

Prepared by

Science Policy Research Division
Congressional Research Service

(107)

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WEATHER SATELLITES: AN OVERVIEW *

I. INTRODUCTION

First by the use of kites and balloons, later by the use of instrumented airplanes, the science of meteorology has developed in large part by observing the Earth's turbulent atmosphere from ever higher altitudes. This progression led in the early space age to the development of orbiting weather satellites.

The first successes in photographing the Earth from space came soon after World War II. Some of the V-2 rockets launched from White Sands, New Mexico in the late 1940s were equipped with cameras that photographed portions of the Earth below in order to help determine the rocket's attitude. Cloud patterns naturally appeared in these pictures, as they did in later Aerobee rocket tests (1954), Project Hugo tests (1958) 1/ and particularly clearly in an Atlas rocket test on August 24, 1959. The significance of these high-altitude pictures was not lost on meteorologists.

Scientific feasibility reports and discussions of the possible meteorological uses of orbiting satellites were under way as early as 1951 at various branches of the Department of Defense, at the offices of their contractors, and at the U.S. Weather Bureau. 2/ Planning of satellites with meteorological applications continued throughout the 1950s.

Vanguard 2, launched on February 17, 1959, was intended to provide cloud cover data, but precession (wobbling) prevented the acquisition of data from what would have been the world's first weather satellite. In the same year Explorer VI (launched August 7, 1959) became the first satellite to return

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1/ Widger, William K. Meteorological Satellites. New York, Holt, Rinehart and Winston, 1966. p. 47.

2/ Greenfield, S. M., and W. W. Kellogg. Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle. RAND Corporation Report No. R-365. Aug. 1960 (Unclassified edition of RAND Report No. R-218, issued 1951). (Reference from Widger, op. cit., p. 289).

* Prepared by Marcia S. Smith, Specialist in Aerospace and Telecommunications Systems, CRS, and John (Tony) Reichhardt, consultant. Information in this report is current as of Dec. 31, 1981.

usable photos of the Earth, and Explorer VII (launched October 13, 1959) successfully carried an instrument to measure the Earth's budget of incoming and outgoing energy. Other versions of this non-photographic experiment flew on later TIROS and Nimbus satellites.

In the spring of 1958, the Defense Department's Advanced Research Projects Agency (ARPA) called for a committee formed from representatives of the U.S. Weather Bureau, Army, Navy, Air Force, the National Advisory Committee on Aeronautics (NACA, later to become NASA) and the RAND corporation with the goal of developing a meteorological satellite system. This project, transferred to NASA in April 1959, led to the building and launch of the Nation's first weather satellite, TIROS 1, in 1960.

Since then, the U.S. civilian meteorological satellite program has been a succession of experimental satellites followed by operational systems. NASA is in charge of the experimental programs, while the Department of Commerce (through the National Oceanic and Atmospheric Administration—NOAA, and previously through the Environmental Satellite Services Administration—ESSA) is in charge of the operational systems.

There have been five NASA experimental meteorological satellite programs to date, with launches in the year indicated: TIROS (1960-1965), Nimbus (1964-1978), TIROS M/ITOS 1 (1970), SMS (1974-1975), and TIROS N (1978). The four operational meteorological satellite programs are: TOS/ESSA (1966-1969), ITOS/NOAA 1-5 (1970-1976), GOES (1975 to present), and TIROS N/NOAA 6-7 (1979 and 1981). The meteorological satellites are divided between those that are placed in high geosynchronous orbits (SMS and GOES), and those in lower polar orbits (all the rest). At the end of 1981, the U.S. civilian meteorological satellite system consisted of two geosynchronous satellites (GOES 4 and 5) and two in polar orbits (NOAA 6 and 7). 3/

All launches of U.S. satellites designed principally for meteorological purposes are shown in table 1. It should be noted that other satellites have carried experimental meteorological sensors, most notably the Application Technology Satellite (ATS) series used primarily for communication satellite experiments. These are not included in the table, but are discussed in the text. Also, the meteorological satellite program is inextricably linked with other remote sensing programs such as those for ocean sensing, Earth resources, and exploration of the upper atmosphere.

The Department of Defense operates its own polar-orbiting Defense Meteorological Satellite Program (DMSP), and DOD provides weather data to the civil sector through NOAA, and vice versa.

3/ Some data can also be obtained from several of the older satellites if necessary.

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TABLE 1. U.S. Meteorological Satellites 1960-1981

NAME	LAUNCH DATE	PURPOSE/COMMENTS
Tiros 1	Apr. 1, 1960	First global cloud cover picture.
Tiros 2	Nov. 23, 1960	Optical and infrared photos of global cloud cover.
Tiros 3	July 12, 1961	Good cloud cover picture; infrared data.
Tiros 4	Feb. 8, 1962	Supported Friendship 7 flight. Transmitted cloud cover photos till June 1962.
Tiros 5	June 19, 1962	Infrared system inoperative. Good cloud cover pictures.
Tiros 6	Sept. 18, 1962	Infrared sensor omitted.
Tiros 7	June 19, 1963	Transmitted data for nearly 3 years.
Tiros 8	Dec. 21, 1963	Carried Automatic Picture Transmission (APT) system, allowing real-time readout of local cloud pictures using an inexpensive ground station.
Nimbus 1	Aug. 28, 1964	Earth orientation allowed complete global cloud cover pictures every 24 hours. Carried APT for local readout.
Tiros 9	Jan. 22, 1965	First Tiros "cartwheel" configuration for increased coverage of world cloud cover.
Tiros 10	July 2, 1965	First U.S. weather service-funded spacecraft. Has two T.V. cameras similar to Tiros 6.
ESSA 1	Feb. 3, 1966	Initiated the Tiros Operational Satellite system (TOS). Designated ESSA for the Environmental Science Service Administration (later renamed NOAA for National Oceanic and Atmospheric Administration).
ESSA 2	Feb. 28, 1966	Permitted local read-out of daylight cloud cover by APT TV system. Advanced version of cartwheel design.
Nimbus 2	May 15, 1966	Similar to Nimbus 1. Completed more than 2 1/2 years of operation with three-axis stabilization.
ESSA 3	Oct. 2, 1966	First Advanced Vidicon Camera system in Tiros/TOS series; also carried infrared Earth heat balance sensor.

TABLE 1. U.S. Meteorological Satellites (cont.)

NAME	LAUNCH DATE	PURPOSE/COMMENTS
ESSA 4	Jan. 26, 1967	Advanced version of cartwheel configuration. Good APT pictures returned.
ESSA 5	Apr. 20, 1967	Carried Advanced Vidicon Camera system.
ESSA 6	Nov. 10, 1967	Carried two TV systems used for APT ground station.
Nimbus B	May 18, 1968	Launch vehicle destroyed by range safety officer after 2 minutes. Carried eight experiments, including a radioisotopic thermoelectric generator.
ESSA 7	Aug. 16, 1968	Permitted daily photos of entire globe.
ESSA 8	Dec. 15, 1968	Carried two APT camera systems to obtain daily cloud photos of entire globe.
ESSA 9	Feb. 26, 1969	Last mission of TOS series.
Nimbus 3	Apr. 14, 1969	Carried experiments identical to those on the unsuccessful Nimbus B.
Tiros M (ITOS 1)	Jan. 23, 1970	Second generation operational meteorological satellite, carrying TV, APT and scanning radiometers for global cloud data for remote and local readout, both day and night.
Nimbus 4	Apr. 8, 1970	Seven of the nine experiments carried are operational.
ITOS A (NOAA 1)	Dec. 11, 1970	Mission designed to provide improved operational infrared and visual observations of Earth cloud cover, both in direct readout and stored modes of operation.
ITOS B	Oct. 21, 1971	Failed due to second stage malfunction. Same mission as ITOS A.
ITOS D (NOAA 2)	Oct. 15, 1972	Same as ITOS A except that a Vertical Temperature Profile Radiometer for atmospheric temperature sounding and a Very High Resolution Radiometer for detailed imaging and sea surface and cloud top temperature measurements were carried.
Nimbus 5	Dec. 11, 1972	Stabilized Earth-oriented platform for the testing of advanced systems, sensing and collecting meteorological and geological data.
ITOS E	July 16, 1973	Failed due to second stage malfunction. Same mission as ITOS D.

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TABLE 1. U.S. Meteorological Satellites (cont.)

NAME	LAUNCH DATE	PURPOSE/COMMENTS
ITOS F (NOAA 3)	Nov. 6, 1973	Same mission as ITOS D.
SMS 1	May 17, 1964	Part of a global network of geostationary environmental satellites with the objective of providing repetitive Earth imaging of the same area in the visible and infrared spectra.
ITOS G (NOAA 4)	Nov. 15, 1974	Same mission as ITOS D.
SMS 2	Feb. 6, 1975	Supplement for SMS 1.
Nimbus 6	June 12, 1975	Carried nine advanced instruments for remote sensing of the atmosphere.
GOES 1	Oct. 16, 1975	Geostationary Operational Environmental Satellite. Operational version of SMS. Replaced SMS 1.
ITOS H (NOAA 5)	July 29, 1976	Same mission as ITOS D. Last of this series.
GOES 2	June 16, 1977	Second in the series.
GOES 3	June 16, 1978	Third in the series.
TIROS N	Oct. 13, 1978	Third generation polar orbiting experimental spacecraft to provide improved meteorological data. Later made part of operational system.
Nimbus 7	Oct. 24, 1978	Flight tested advanced sensors and technology basic to conducting experiments in pollution monitoring, oceanographic, and meteorological fields.
NOAA 6	June 27, 1979	Operational version of TIROS N.
NOAA B	May 29, 1980	Launch vehicle malfunction placed satellite in wrong orbit; not usable.
GOES 4	Sept. 9, 1980	Fourth in the series.
GOES 5	May 22, 1981	Fifth in the series.
NOAA 7	June 23, 1981	Second operational TIROS N satellite.

Table prepared by Marcia S. Smith, Congressional Research Service. Source: NASA Historical Pocket Statistics (1979) and NASA Pocket Statistics (1980 and 1981).

II. TIROS 1 AND ORGANIZATION OF OPERATIONAL METEOROLOGICAL SATELLITE STRUCTURE

The United States launched its first weather satellite on April 1, 1960. The NASA experimental satellite was named the Television and Infrared Observation Satellite, or TIROS. Pictures from TIROS 1 gave meteorologists, for the first time, an ability to constantly monitor the weather. Developing storms and frontal activity were easily seen in the space imagery, [4] and the photos gave meteorologists their first total view of weather patterns. They revealed a degree of organization never realized from terrestrial and aircraft observations.

The success of TIROS 1 prompted interest in an operational meteorological satellite system. At NASA's initiative, a Panel on Operational Meteorological Satellites (POMS) was established in October 1960 as an interagency working group under the auspices of the National Coordinating Committee for Aviation Meteorology. The agencies participating in the panel were the Departments of Defense (Army, Air Force and Navy) and Commerce (U.S. Weather Bureau), the Federal Aviation Administration, and NASA.

In April 1961 POMS issued a plan for a national operational meteorological satellite system. [5] The POMS plan recommended that the Weather Bureau [6] assume management responsibility for the national operational meteorological satellite system, or NOMSS. Under contract to the Department of Commerce, NASA would develop and procure the spacecraft and launch vehicles. NASA would continue such ground support activities as tracking and spacecraft control and programming, while the Weather Bureau would be responsible for data processing and dissemination. Upon the approval of the POMS plan by the White House National Aeronautics and Space Council (with the concurrence of the Budget Bureau) a specific request for funds for implementation of the plan was sent to the President. On May 25, 1961, President Kennedy addressed the Congress on "Urgent National Needs." 7/ Along with a call to land a man on the Moon by decade's end, he requested additional funds for NASA and the Weather Bureau to implement the operational weather satellite system. A total of $50.2 million was appropriated for NASA, 8/ and $48 million was appropriated to the Weather Bureau. 9/

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[4] Space imagery broadly includes all types of images, likenesses, and graphic representations ranging from high resolution photographs and television to the extremely low resolution arrays of dots from banks of photo cells used to estimate cloud cover.

[5] U.S. National Coordinating Committee for Aviation Meteorology. Panel on Operational Meteorological Satellites. Plan for a National Operational Meteorological Satellite System. Washington, U.S. Govt. Print. Off., 1961. 26 p.

[6] In 1965 the Weather Bureau was combined with the Coast and Geodetic Survey and the Central Radio Propagator Laboratory of NBS to form the Environmental Science Services Administration (ESSA) in the Department of Commerce. In 1970, when the National Oceanic and Atmospheric Administration (NOAA) was formed within the Commerce Department, weather satellite programs became the responsibility of that agency.

Thus, in a period of less than six months, the POMS had presented its recommendation for an operational system and had it approved by the President's Science Advisor, the Space Council, the Budget Bureau, the President, the Congress, and had virtually all of the necessary funds appropriated for Fiscal Year 1962.

It is interesting to note that during congressional hearings on the national meteorological satellite system, there was some discussion as to whether NASA or the Department of Commerce should manage the system. 10/ Those who advocated management within NASA reasoned that the entire civilian space program should be managed within one agency. Those who thought that the system should be managed by the Weather Bureau within the Department of Commerce felt that the user agency should have control over the system. Unlike later debates centering on an operational Landsat system, at no time was NASA's legal authority to manage operational satellite systems questioned, as it has been in recent years.

III. U.S. METEOROLOGICAL SATELLITES

A. Polar-Orbiting Satellites

1. TIROS

The evolution of U.S. weather satellites through changes in technology, orbital configurations, instrumentation and data handling methods began with the TIROS program, which ran from 1960 to 1965.

There were ten TIROS satellites launched between April 1960 and July 1965, and all ten were successful. TIROS data were transmitted as late as July 1967. Although the original life expectancy of the spacecraft was to have been from three to four months, all but TIROS 1 exceeded this; TIROS 8 had the longest useful lifetime, returning data for three and a half years.

7/ House Document No. 174, 87th Cong., 1st Sess.

8/ P.L. 87-141, Aug. 17, 1961.

9/ P.L. 87-332, Sept. 30, 1961.

10/ U.S. Congress. House. Committee on Science and Astronautics. National Meteorological Satellite Program. Hearings, 87th Cong., 1st Sess. July 25, 26, and 27, 1961. Washington, U.S. Govt. Print. Off., 1961.

TIROS 1-4 were launched typically into 720 kilometer-high orbits inclined at an angle of 48 degrees to the Equator, allowing photographic and instrument coverage to about 55 degrees latitude (north and south), but not of the polar regions. For TIROS 5-8 the orbital inclination was changed to 58 degrees, making coverage up to 65 degrees possible.

The last two TIROS were placed in near-polar orbits. TIROS 10 added another improvement--it was the first TIROS to be placed in a sun-synchronous orbit, meaning that it passed over each longitude at the same local time each day, enabling it to view each place on Earth under uniform lighting conditions. The TIROS orbits, then, had the spacecraft photographing a different swath of the turning Earth on each orbital pass (each TIROS orbit took about 97-100 minutes). This is the same principle applied in all low-orbit weather satellites.

The satellite itself weighted from 121 to 135 kilograms, depending on the onboard instrumentation, with a cylindrical shape often compared to that of an oversized hatbox. Instruments for the first eight TIROS satellites where mounted in the baseplate, so they looked down through the bottom of the spacecraft at the Earth. The satellite was spin-stabilized, but its spin axis was not aligned with reference to the Earth, so the flat baseplate did not always remain parallel to the Earth's surface.

As a result, the video cameras pointed at the Earth for only one quarter to one third of each orbit. During the remainder of the time they pointed uselessly at outer space. TIROS 9 inaugurated an improvement with the "cartwheel" configuration, in which the spin axis of the spacecraft was held perpendicular to the plane of the orbit so that in effect the satellite rolled along the orbit like a wheel on its rim. Instead of mounting the cameras so that they pointed down from the base of the satellite, the two cameras were placed on the satellite rim facing outward, 180 degrees apart. Thus, TIROS 9 increased by 3 to 4 times the photographic capability of TIROS 1.

The primary sensors on TIROS were two television (vidicon) cameras, one wide-angle and the other narrow-angle, and low and medium resolution infrared radiometers. The TV cameras provided cloud pictures. The infrared radiometers returned data that could be used to determine the temperatures of clouds, their height and moisture content. 11/ Operation of TIROS consisted basically of commanding the satellite to photograph and to transmit pictures and other data to the ground. The satellite control center computed the command signals to be sent to the satellite and passed this information to the command and data acquisition stations (CDA). The CDA stations transmitted the commands to TIROS as it passed overhead. When the satellite reached the sunlit portion of the orbit, a clock system in the satellite started the camera. Every 30 seconds after start time the camera took a picture, until 32 pictures were recorded on the satellite's magnetic tape. A limit of 32 pictures per camera was imposed by the capacity of the magnetic tape storage. As the satellite returned to within telemetry range, the CDA station commanded the satellite to transmit stored pictures and other data, to transmit direct pictures if the station was in daylight, and finally to set the clock for the next orbit.

11/ Infrared sensors were not included on TIROS 6 in order to speed up its preparation for launch after one of the cameras on TIROS 5 failed July 6, 1962.

An important development in NASA's experimental program was automatic picture transmission (APT) first carried on TIROS 8, in 1963. For some nations the cost of building facilities for receiving data from the United States was prohibitive. In addition, many nations lacked the technical capability to process and analyze the data. APT systems make spacecraft images available at a minimum cost to any user within radio range of the satellite. A video picture is shuttered, then scanned slowly for immediate transmission to Earth rather than later "dumping" at a large CDA station. The transmission is made on a relatively narrow bandwidth so that the signal can be received and displayed by low-cost ($20,000-$25,000) receiving sets. The APT channel of a satellite operates continuously, thus allowing any nation, group, or even private citizen to secure an instantaneous picture of its atmosphere as a satellite equipped with APT passes overhead. APT data are now received by 871 known stations in 123 countries throughout the world.

One of the goals of the TIROS experimental program was to integrate satellite imagery into the process of weather forecasting. With imagery provided by NASA, meteorologists learned to use the new satellite data in the preparation of their forecast charts, and TIROS began to be used operationally in a limited way. The types of information which could be gleaned from the photos increased in number as photointerpretation techniques improved. As an example, TIROS 2 showed that weather satellites might be used to indicate ice boundaries on water, when it photographed the breakup of pack ice on the St. Lawrence River.

After the launch of TIROS 6 on September 18, 1962, there were at least two TIROS satellites operational at any one time through the end of the program.

2. Nimbus

The next generation of NASA experimental weather satellites was the Nimbus series, with seven successful launches from 1964 to 1978. 12/

The Nimbus program was initiated by NASA early in 1960, its goal to develop an observatory system capable of meeting the research and development needs of the Nation's atmospheric and Earth scientists. Nimbus had been expected to succeed TIROS in the operational weather satellite system, but cost increases and technical problems prompted the decision to use Nimbus only for research purposes and to develop a new operational satellite based on proven TIROS technology. Consequently, Nimbus became the Nation's principal satellite program for remote sensing research in low orbits.

Nimbus 1 was launched on August 28, 1964. This more sophisticated satellite was approximately three times the size and weight of TIROS, and its modular design allowed a variety of experiments to be added to the basic power, communications and stabilization subsystems on successive flights. Nimbus 1 carried three instruments, and each "observatory" grew significantly in sophistication, weight and performance.

12/ Nimbus B, launched May 18, 1968, never achieved orbit.

Unlike TIROS, Nimbus kept its instruments pointing continually down at the Earth with its three-axis Earth-oriented stabilization system. Nimbus satellites were placed in sun-synchronous near-polar orbits which provided global coverage twice in each 24-hour period.

The seven Nimbus spacecraft have been used for development, testing and application of a number of new and advanced meteorological and geophysical remote sensing instruments, cameras and associated data-transmission and processing techniques. Nimbus satellites flight tested the APT (Automatic Picture Transmission) system used on the ESSA series 13/ and the high-resolution infrared scanning radiometer (HRIR). They tested the forerunner to the vertical temperature profile radiometers used on the ITOS series (providing the first satellite soundings of the atmosphere), as well as data collection and relay devices to be used on future satellites.

Another Nimbus achievement (on Nimbus 1) was the successful testing of the Advanced Vidicon Camera Subsystem (AVCS), which greatly improved the quality and resolution of satellite cloud photos. The AVCS was then used in coordination with Automatic Picture Transmission (APT) cameras in the ESSA series. Nimbus 6 was used in yet another capacity--the tracking of explorers. In 1978 a Japanese explorer traveling alone to the North Pole carried a transmitter on his dog sled which sent a signal to Nimbus 6 once a minute so that his position could be tracked. Similarly, a desert expedition through the Western Desert of Egypt was tracked using Nimbus 6 later in 1978.

Nimbus 7, the last of the series, was launched on October 24, 1978. The satellite was the first designed to measure various atmospheric gases and pollutants in the stratosphere and mesosphere. Nimbus 7 carried a total of eight sensors, several of which were improved versions of instruments flown on previous Nimbus spacecraft. The instruments supported three disciplines: pollution monitoring, meteorology, and oceanography.

One device, the Coastal Zone Color Scanner (CZCS) was particularly important to oceanographers, in that it allowed analysis of ocean content over larger areas than was possible from ship observations. In addition to mapping chlorophyll, sediment and salinity distribution in coastal regions or open ocean waters (as determined by their characteristic absorption and scattering of light), the CZCS was also used to map temperatures of the waters near the coast or farther out at sea. The detection of chlorophyll concentration indicates the presence of phytoplankton, and so can be used to assess the likelihood of finding fish in a certain part of the ocean.

The CZCS project evolved from a series of measurements made between 1969 and 1973 to determine if ocean color could be sensed through the Earth's atmosphere, and if sufficient information of interest to oceanographers could then be extracted from the color. 14/ The instrument placed on board Nimbus 7

13/ TIROS 8 was actually the first satellite to fly APT cameras, but the spacecraft's spin prevented a full test of the system as it was operationally designed.

14/ Hovis, Warren. The Nimbus Coastal Zone Color Scanner (CZCS) Program. In Gower, J. F. R., ed. Oceanography From Space. N.Y., Plenum Press, 1981. p. 213.

is a multispectral line scanner, sensitive in six channels--five bands of the visible spectrum and one in the infrared. Infrared measurements provide information on the temperature of coastal waters as well as the open ocean. All six channels operate by day, whereas only the infrared (10.5-12.5 micrometer) instrument can return data at night.

Since it was anticipated that surface Sun glint would pose a serious threat to ocean color observations, a feature was included in the CZCS that allows the angle of a scan line to be tilted either ahead of or behind the spacecraft.

At the beginning of the Nimbus 7 operation, two hours per day were allocated to CZCS operation, but this was later reduced. Scheduling of CZCS imagery is carried out on a priority basis, and ship operations where simultaneous measurements can be conducted with space imagery are given highest priority. There are also certain areas of high priority coverage, such as U.S. and European coastal waters.

The CZCS instrument was still returning data from space at the end of 1981, and methods of using the data were undergoing evaluation by the community of oceanographers. At a joint COSPAR/SCOR/IUCRM symposium held in 1980 to discuss space oceanography 15/, a number of papers were presented dealing specifically with CZCS. In an introductory paper, H. R. Gordon and Y. R. Morel referred to the "high quality of the CZCS imagery" and stated:

> It is now clear that there is considerable horizontal structure in the color of the ocean, and that the CZCS is without doubt capable of delineating this structure even in the presence of very turbid atmosphere.

In the same paper the authors referred to the successful utilization of CZCS data in biological research by the National Marine Fisheries Service, the Scripps Institution of Oceanography and the Southeast Fisheries Center. CZCS data had influenced the choice of cruising areas for research vessels.

Another application of CZCS data has been in the West Coast Fisheries Demonstration Project, conducted in 1981, where CZCS images sent by facsimile to ships at sea have correlated very well with conditions observed on the ocean. Although reflective pollutants such as acid waste and sewage sludge show up clearly in CZCS imagery, and more use of this capability is possible with tracer dyes, little research has been done on the CZCS's ability to monitor water pollution. 16/

15/ COSPAR is the Committee for Space Research, and SCOR is the Scientific Committee for Oceanic Research, both of the International Council of Scientific Unions (ICSU). IUCRM is the Inter-Union Commission on Radio Meteorology. The symposium papers are reprinted in the previously cited Oceanography from Space, edited by Gower.

16/ Dr. Warren Hovis, of NOAA's National Environmental Satellite Service (NESS). Telephone communication, Apr. 5, 1982. Dr. Hovis headed the CZCS experiment team.

An improved CZCS, with more spectral bands and a greater amount of data returned during each day of operation, was to have flown on the National Oceanic Satellite System (NOSS) before that program was cancelled. NOAA is conducting a study of placing an improved operational CZCS on the NOAA H weather satellite. In addition, an ocean color experiment was flown on the second test flight of the Space Shuttle in 1981.

Nimbus spacecraft, the forerunners of the highly successful Landsat earth resources satellites, have returned a wealth of new data applicable to meteorology, oceanography, geology and hydrology, and continue to transmit these data at the end of 1981.

3. TOS/ESSA

The first operational meteorological satellite system was inaugurated in February 1966 with the launch of ESSA 1. Administratively, the new system was managed by the National Environmental Satellite Center (NESC) of the Environmental Science Services Administration (ESSA) in the Department of Commerce. 17/ In operating the National Operational Meteorological Satellite System, NESC was responsible for: command and control of the satellite in orbit; data acquisition, processing, dissemination and archival; maintenance and improvement of ground data handling systems; future spacecraft system plans; coordination with NASA for the development of new and improved sensor systems; and the procurement of spacecraft, launch vehicles and launch services. It was also a function of NESC to conduct research and development on the analysis and application of satellite data. Satellite technology research and development, and the launching of spacecraft were to remain NASA's responsibilities.

Technically, the new system employed the TIROS Operational Satellite (TOS) spacecraft (renamed ESSA, for Environmental Survey Satellite, upon reaching orbit successfully) which were based on the proven technology of the TIROS experimental satellites. ESSA 1 was identical to the TIROS 9 spacecraft used to test the TOS system concept. Later ESSA satellites were considerably modified and improved.

The TOS system consisted of two types of ESSA spacecraft in orbit simultaneously. One type (those assigned odd numbers) was equipped with an Advanced Vidicon Camera System (AVCS), which provided global coverage by storing pictures for later transmission to CDA stations in Alaska or Wallops Island, Virginia. From there the pictures and data were relayed to Washington, D.C. for processing and analysis. The second type (even numbers) was equipped with direct transmission APT cameras. It photographed and immediately sent the pictures to APT ground stations within range of the satellite.

Operation of the ESSA series was much the same as that of the TIROS series. The near-polar sun-synchronous orbits of the ESSA spacecraft permitted complete

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17/ Later renamed the National Environmental Satellite Service (NESS) when NOAA was formed in 1970.

Earth coverage. A command to photograph was sent to the satellite so that pictures were taken over the sunlit side of the Earth. The greater altitude at which later ESSA satellites operated made possible complete photographic coverage with only six pictures per orbital pass over the sunlit side of the orbit. Twelve pictures, with 50 percent overlap from picture to picture, were normally acquired on each pass. Thus, the satellite provided global coverage by means of 144 to 156 pictures every 24 hours. TIROS 9 and ESSA 1 required between 450 and 500 pictures for the same overlapping coverage.

4. ITOS/NOAA 1-5

With the launch of the first improved TIROS Operational Satellite (ITOS) in 1970, the second generation of polar-orbiting satellites came into being. It dramatically exceeded the capabilities of the first generation TOS/ESSA series. ITOS coincided with the formation of the National Oceanic and Atmospheric Administration (NOAA) which assumed the duties of the now defunct ESSA.

ITOS 1, 18/ NASA's experimental prototype for this satellite, was launched on January 23, 1970 and became operational in June 1970. NOAA 1 19/, the first NOAA operational spacecraft of the ITOS series, was launched December 11, 1970 and contained the same instrument package as ITOS 1.

The ITOS spacecraft was designed to perform the work of a pair of ESSA spacecraft. It had APT as well as AVCS capability, permitting the satellites to transmit both real-time photographs and stored images. Night-time coverage was provided by the addition of a Scanning Radiometer (SR). SR data were stored on magnetic tape for later readout at the CDA stations and also were broadcast through the APT transmitter for local ground reception. These capabilities permitted operational day and night coverage for the first time.

In addition, the ITOS/NOAA satellites carried a Solar Proton Monitor, the first nonmeteorological instrument to be carried on operational satellites. Measurement of the solar proton flux is useful for estimating the degree of activity of the Sun. Such information can be used in forecasts of radio communications conditions. They also carried a flat plate radiometer (FPR) which furnished atmospheric heat balance measurements.

NOAA 2, launched October 15, 1972, was redesigned to incorporate two new instruments and to eliminate the APT and AVCS cameras as well as the flat plate radiometer. With the addition of the very high resolution radiometer (VHRR) and the vertical temperature profile radiometer (VTPR), NOAA 2 became the first weather satellite to have no cameras and to rely entirely on radiometers for visual and infrared images, as well as the first to carry an operational instrument capable of obtaining vertical temperature profiles of the atmosphere over most of the Earth.

18/ Previously designated TIROS M.

19/ Previously designated ITOS A.

The VHRR sensor measures cloud top temperatures or ground and sea surface temperatures in clear areas, both by day and by night, and transmits these data in real time to high resolution picture transmission receiving stations (HRPT). 20/ In addition, eight minutes of data per orbit may be stored in the satellites for later playback to the CDA stations. The operation of the two-channel VHRR is similar to that of the scanning radiometer, but the data are of much higher resolution. One channel measures reflected visual radiation and the other measures infrared radiation. The VHRR data provide more contrast between the Earth and clouds than do the SR data.

NOAA 3, 4 and 5 were identical to NOAA 2. NOAA 5 was deactivated on July 1, 1979, signalling the end of the ITOS/NOAA series.

5. TIROS N/NOAA 6-7

The launch of the TIROS N satellite on October 13, 1978, inaugurated the third and present generation of polar orbiting environmental satellites. 21/ TIROS N carried several improved instruments. One was the Advanced Very High Resolution Radiometer (AVHRR) that had four spectral channels (instead of two) to provide day and night sea surface temperatures, ice, snow and cloud cover information. TIROS N also carried the TIROS Operational Vertical Sounder (TOVS) package to provide improved temperature and moisture vapor content measurements of the atmosphere. One of the three TOVS instruments operated in the microwave region which can penetrate cloud layers, so data can be returned regardless of the amount of cloud cover. The spacecraft also had an upgraded Space Environmental Monitor to give more accurate alerts of high energy solar radiation levels, which is important to manned spacecraft missions, high altitude commercial aircraft flights, long-range communications, and electric power distribution networks.

TIROS N also carried a Data Collection and Location system provided by France, known as Argos, that represented an improvement over the data and collection systems on geostationary satellites. It was capable of receiving data from fixed or moving platforms on land, sea and air, and determining the precise geographic location of each one. This was used to calculate the velocity of the fluid on which the platform "rode."

The TIROS N spacecraft was technically a NASA experimental satellite, but it was used operationally. Operational versions of this series continue the NOAA numbering system, and the first of these was NOAA 6, launched June 27, 1979. It was identical to TIROS N. NOAA 7, launched on June 23, 1981, was essentially the same spacecraft with the exception of another channel added to the AVHRR 22/ to improve measurements of sea surface temperatures.

20/ Only 47 stations worldwide are equipped to receive the digital HRPT data, whereas some 871 can receive the lower resolution APT transmissions.

21/ The TIROS N spacecraft is based on the Block 5D bus developed for the Air Force and used in the Defense Meteorological Satellite program.

22/ Actually, one channel was split in two.

The TIROS N series of spacecraft are the first all-digital polar orbiters. The information flow from each TIROS N satellite is 1.33 million bits per second, increasing by more than 100 percent the burden upon the communications and data processing system as compared to the previous generation of polar-orbiters. To meet this demand, the system needed technological improvements: an automated command and control system, new computers at the CDA stations, mini-computers on board the satellites for some data processing prior to transmission; and data transmission via a commercial communications satellite from the CDAs to National Environmental Satellite Service (NESS) in Suitland, Maryland. The flow rate is so large that it must be slowed before processing, so a bank of 14 staging computer disks temporarily holds the dada for feeding into a trillion-bit memory archiving system. From there, the information is moved to other computers for the generation of quantitative products which are distributed to users worldwide.

B. Geostationary Satellites

The geostationary satellite represents a great advance in meteorological satellite capability. Although it is incapable of viewing polar regions, the advantage of its 35,800 kilometer-high geosynchronous orbit is that it is relatively immobile in relation to the Earth's surface and can therefore provide continuous coverage of the same portion of the globe. Continuous coverage is particularly significant for the detection and tracking of severe storms which are small in size and transient in nature. These satellites enable meteorologists to study tornadoes which strike quickly and with little warning. They also permit constant monitoring of larger weather patterns such as tropical storms. In addition, it is possible to measure the velocity of winds by tracing selected clouds imaged at short intervals and deriving the direction and speed of their movement.

1. ATS

Preliminary meteorological experiments were first performed aboard the NASA experimental synchronous satellites known as the Applications Technology Satellites (ATS). ATS 1, launched December 6, 1966, was placed into geostationary orbit over the Pacific Ocean at the Equator. Four days later the satellite began continuous photographic coverage of the Pacific basin and Western United States with a spin scan cloud camera which returned the first black and white full-disc pictures of the Earth. ATS 3 was also a major success. It carried a color spin scan cloud camera and viewed much of North America, the north and south Atlantic Ocean, all of South America and the western edges of Africa and Europe. These cameras proved the usefulness of weather satellite imagery from the high synchronous orbit.

Several important weather communications techniques were tested on the ATS system, one of which was the WEFAX experiment. In the WEFAX system the satellite serves as a relay station for broadcast of weather information of interest to the portion of the globe covered by the satellite. Information is in the form of satellite pictures and weather maps, and the broadcasts can be received by anybody who has the required receiving set. 23/ WEFAX serves ships at sea as well as land stations, and for those nations within view of a WEFAX-equipped satellite it offers an important supplement to the APT service furnished by the NOAA satellites. At the end of 1981 there were 145 stations receiving WEFAX broadcasts worldwide from geostationary GOES satellites (see below).

Although the ATS satellites were able to view the Earth only in daylight, their successes formed the technological base from which the SMS/GOES program began.

2. SMS/GOES

On May 17, 1974, the first NASA Synchronous Meteorological Satellite (SMS) was launched. Initially it was used to support the Global Atmospheric Research Program (GARP) (see below). SMS 2 was launched on February 6, 1975. GOES 1 (Geostationary Operational Environmental Satellite), the first NOAA-funded operational spacecraft of this series, was launched on October 16, 1975. It was followed by GOES 2, 3, 4, and 5 in 1977, 1978, 1980 and 1981, respectively. With these satellites the useful camera coverage and communications range extends westward from Western Europe and Africa to the western Pacific Ocean and includes all of North and South America.

The principal instrument of the SMS series and the first three GOES satellites was an improved radiometer, the Visible and Infrared Spin-Scan Radiometer (VISSR). It took visual images of the Earth's surface and cloud cover, and took infrared sea surface temperature data. The radiometer could scan the full portion of the Earth within its view in approximately 20 minutes. If meteorologists wished to monitor a severe storm, the satellite could limit its scan and provide a picture of the storm area every 15 or even every 5 minutes. Thus, in the limited scan, coverage of territory is traded for frequency of scan in a lesser area.

GOES 4, launched on September 9, 1980, carried an improved version of the VISSR which provided not only imagery, but also atmospheric temperature and water vapor soundings as a function of altitude in the atmosphere. Called the VAS (for VISSR Atmospheric Sounder), it has 12 infrared sensing bands compared to one such channel on the VISSR. At its current state of development, the VAS cannot obtain sounding data and imagery at the same time, however. GOES 5, launched on May 22, 1981, also carried a VAS, and replaced an older-model SMS/GOES over the eastern half of the United States. 24/

Data from the VAS are important in forecasting and monitoring the strength and course of highly localized severe storms, such as thunderstorms, hurricanes and severe winter snowstorms. The inclusion of VAS—an experimental instrument—on board an operational spacecraft was part of NASA's operational satellite

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23/ WEFAX receivers cost from $12,000-$15,000 in 1981.

24/ Several of the geosynchronous satellites launched to date have been transferred to different "hovering" spots during their operational lifetimes.

improvement program designed to save funds by combining research and operational sensors when possible.

The SMS/GOES satellites also carry a package of Space Environmental Monitor (SEM) instruments, as do the NOAA satellites. The SEM instruments include a magnetometer, a solar X-ray telescope, an energetic particle monitor, and, on GOES 4 and 5, a High Energy Proton and Alpha Detector (HEPAD). These instruments take measurements of solar activity and provide data on the Sun's interaction with terrestrial fields.

Another important payload of the SMS/GOES satellites is the Data Collection System (DCS) which collects and relays environmental data sensed by more than 1,500 widely dispersed platforms such as river and rain gauges, seismometers, tide gauges, buoys, ships and automatic weather stations. Each platform must be equipped with a data collection platform radio set to provide the communication link between the platform and the satellite. Platforms then transmit sensor data by radio, either at scheduled intervals or upon interrogation from the satellite. Platforms may also operate in an emergency alarm mode, during which a signal is transmitted immediately whenever an observational parameter exceeds a preset threshold value. Data received by the satellite are transmitted to the Wallops Island CDA Station and relayed to the World Weather Building in Camp Springs, Maryland. From here the data are disseminated by paper tape fed into a telephone system using commercial circuits. The GOES DCS began service on August 18, 1975. The SMS/GOES satellites also carry the WEFAX capability.

C. Existing Operational Meteorological Satellite System

The current operational meteorological satellite system is comprised of both polar-orbiting and geostationary satellites. The polar-orbiting satellites obtain quantitative global environmental data used to derive profiles of atmospheric temperature and moisture, sea surface temperature observations, and snow and ice coverage, and they relay environmental data from fixed and moving remote platforms. All these data and products are used in numerical weather analysis and prediction, oceanographic, hydrologic, agricultural and solar radiation studies. Data from the polar orbiters are received by 871 APT stations around the world as the satellite passes overhead.

The geostationary satellites provide the repetitive 24-hour images that are needed to detect, track and monitor the growth and decay of severe weather systems in the temperate and tropical latitudes. They also continuously collect environmental data from fixed platforms and are used to retransmit satellite-derived products to national and international users via Weather Facsimile (WEFAX).

At the end of 1981 two polar orbiters (NOAA 6 and NOAA 7) and two geosynchronous satellites (GOES 4 and GOES 5) were operational. The two NOAA satellites are in orbits spaced apart in such a way that they provide maximum daylight coverage of the whole globe. GOES 4 is situated at 135 degrees west longitude, and covers the Western part of the United States and the Pacific. GOES 5 is over the equator at 85 degrees west longitude, and so looks down on the eastern and Atlantic side of the continent.

IV. FUTURE METEOROLOGICAL SATELLITES

In the immediate future, the United States weather satellite program will continue with the successful dual system of GOES geostationary and NOAA/TIROS N polar orbit satellites. GOES F, planned for launch in 1983, will be the same spacecraft as GOES 4 and GOES 5. The earliest instrument changes anticipated in the GOES series are for GOES G, tentatively scheduled for launch in 1984.

At the end of 1981 it was not certain what those changes might be. Planners in the National Environmental Satellite Service (NESS) have proposed that contract bidders for the building of later GOES satellites research and develop new instrument changes that would increase the satellite's performance as a meteorological sensor. In addition, planners in NASA's Office of Space Science and Applications are assessing the VAS infrared sounder and its future scientific capabilities as an operational instrument.

Whatever the changes in instrumentation, an established goal is to keep two of these geostationary satellites over American longitudes at any one time. Launch plans for future GOES satellites will likely be geared to the working health of spacecraft already in orbit.

Polar orbiters will continue with the existing TIROS N model spacecraft, with only slight modifications to accommodate new instrument payloads. NOAA E, scheduled for February 1983, will carry the international Search and Rescue (SARSAT) payload. NOAA D, scheduled for launch in August 1984, will not. 25/ NOAA F and succeeding NOAA satellites are scheduled for launch at 18-month intervals after the launch of NOAA D. By the end of 1981, NOAA had contracted to build through spacecraft "J" in the series. Beginning with NOAA F the satellites will carry the SARSAT payload as well as two experiments new to the TIROS N series—the Earth Radiation Budget Experiment (ERBE) and the Solar Backscatter Ultraviolet (SBUV) radiometer. Both of these are based on technologies used in the Nimbus satellite series.

The ERBE instrument is designed to provide data on the Earth's balance of incoming and outgoing radiant energy. The SBUV experiment detects ozone concentrations in the atmosphere as part of NOAA's program to monitor pollutants and minor constituents of the atmosphere.

For later TIROS N/NOAA missions, NASA's Office of Space Science and Applications is researching further advances in the capabilities of the TOVS instruments, including the addition of more spectral channels to the Microwave Sounding Unit and the improvement of sea surface temperature measurements by the infrared temperature sounder.

At the end of 1981 there were no plans for major generic changes in U.S. weather satellites. NASA does have an ongoing research interest in the LIDAR, or "light radar" concept, however. One version would use laser beams to measure such variables as cloud heights and atmospheric densities.

25/ The reversed lettering order here is a result of advancing the NOAA E launch date to get the SARSAT system aloft as early as possible.

Especially valuable would be the measurement of atmospheric wind speeds, a capability lacking in current satellites and one that would mean much to meteorologists. Because laser light beams are monochromatic (of a single wavelength) they could be used for Doppler tracking of winds.

NASA has conducted Doppler LIDAR tests on its Convair 990 aircraft in 1981, and more tests are planned for 1983. Among the questions still to be resolved are how to increase the lifetime of the laser systems and which wavelengths would be the best for meteorological studies. At present too cumbersome and expensive, it is not expected that a LIDAR weather satellite could fly before the early 1990s.

V. PARTICIPATION OF THE UNITED STATES IN INTERNATIONAL METEOROLOGICAL PROGRAMS

The United States participates in international meteorological programs through the World Meteorological Organization (WMO). The WMO is a specialized agency of the United Nations created in 1951 to establish, coordinate and improve meteorological services throughout the world. Membership in the WMO is open to any State, territory or group of territories which maintain a meteorological service. WMO membership numbered 147 in 1981. U.S. meteorological satellites, both polar-orbiting and geostationary, contribute to this effort. WMO members obtain access to meteorological information from satellites indirectly through a WMO network of international, regional and national meteorological centers, and directly from the Automatic Picture Transmission (APT) broadcast.

A. Equipment and Training

Since the launch of the first APT-equipped satellite in 1963, 871 APT receivers have been placed in operation by Government agencies in 12 countries (including the U.S.S.R. and the People's Republic of China) as well as academic institutions, scientific groups, local communities, commerical television stations, Boy Scout troops, and private individuals throughout the world. Although the official cost estimate for an APT terminal is approximately $20,000 to $25,000, home-manufactured receivers have been constructed for considerably less.

The United States has not only developed equipment which can be used internationally, it also provides training in the use of the equipment as well as assistance in processing and interpreting data derived from the equipment. Such aid proved particularly important when the United States switched from video cameras to scanning radiometers on its weather satellites in the early 1970s, since the new images required some adjustment after they were received. The United States has contributed equipment and services through the voluntary assistance plan of the WMO.

B. World Weather Program

The World Weather Program consists of the World Weather Watch (WWW) and the Global Atmospheric Research Program (GARP). The WWW and GARP are the focal points in the WMO for the use of space technology. Meteorology has a dual character as a branch of the physical sciences and as a public service, leading to its peculiar position as part of both basic research and operational systems. As a result, there is a mutual exchange between scientists who use empirical data from operational meteorological systems to better understand weather phenomena and weathermen who use the knowledge gained from experiments to improve their prediction ability. Because of this mutual relation, both the operational (WWW) and scientific (GARP) aspects of the program are discussed in this section.

1. World Weather Watch (WWW)

In December 1961 the United Nations General Assembly, recognizing the potential of space technology, adopted resolution 1721 (XVI) relating to international cooperation in the peaceful uses of outer space. One section of the resolution called upon the WMO to examine the potential value of space techniques in meteorology. The study concluded that there was a need to support a single global meteorological service--the World Weather Watch (WWW).

The operational elements of the World Weather Watch are the Global Observing System (GOS), Global Data Processing System (GDPS), and the Global Telecommunications System (GTS).

a. Global Observing System (GOS) GOS provides meteorological and related environmental data from both satellite and ground-based observations. Space data are derived from both polar orbiters and geostationary satellites. Satellites from the United States, Japan and the European Space Agency (ESA) all contribute. The Soviet Union has promised to provide a satellite as part of this program, but apparently encountered technical difficulties. By December 1981 the Soviets had never launched a geostationary weather satellite.

The present geostationary system includes the two U.S. GOES satellites at 85 degrees W and 135 degrees W longitude, ESA's Meteosat at 0 degrees longitude, and Japan's Himawari, stationed at 140 degrees E longitude. The Global Observing System also includes the subsystem of surface and upperair stations--aircraft, data collection platforms, buoys, ground weather radar stations, instrumented ships, etc.

b. Global Data Processing System (GDPS) This system is designed to make available to the meteorological services of the world processed data and products required for preparing forecasts and warnings and for climatological and research purposes on both a real-time and delayed basis. The GDPS operates on three levels: international, regional and national. The World Meteorological Centers (WMC) are located in Washington, D.C., Moscow and Melbourne, Australia (limited capability). They process data from the GOS and transmit meteorological analyses on a global scale to WMO member nations through the GTS. The Regional Meteorological Centers (RMC) furnish processed data and forecasts on a regional basis. For example, the area of the Caribbean, Central America and northern South America is served by an RMC at Miami. Finally, located in nearly all member WMO nations are the National Meteorological Centers (NMC). They are intended to satisfy data processing needs on the national level, assisted as required by the products of the WMC and RMC network. The integrated GDPS utilizes high-speed computers and data-handling equipment which makes routing and processing large amounts of global data possible with a minimum of duplication of effort.

c. Global Telecommunications System (GTS) The GTS is comprised of the telecommunications facilities for rapid collection and exchange of basic observational and processed data. Like the Global Data Processing System it also operates on three levels: the main trunk circuit (global), the regional telecommunications networks (regional), and the national telecommunications networks (local). GTS issues thousands of bulletins daily. Satellites play an important role in the GTS, and when used in combination with other techniques they vastly improve the overall efficiency of the WWW in obtaining and using data. Collection of data from ocean-based platforms is a good example.

2. Global Atmospheric Research Program (GARP)

In 1962 the United Nations passed resolution 1802 (XVII) inviting the International Council of Scientific Unions (ICSU) through its member unions and national academies to develop an expanded program of atmospheric science research that would complement the programs fostered by the WMO. The result was the 1967 agreement between WMO and ICSU on the Global Atmospheric Research Program (GARP). The program includes theoretical, numerical and observational experiments designed to improve our understanding of the Earth's atmosphere and to develop and test physical-mathematical models.

Global observations are of particular value to the GARP program for several reasons. The particular value of satellites is their global coverage, which is required for two reasons. First, it is needed as a starting point for global weather forecasts that use existing physical-mathematical models of the total Earth atmosphere. The quality of these forecasts reflects directly the completeness of the observations used to describe the present atmospheric state, from which the models then forecast furture states. Second, global observations are needed to test, verify, and improve the performance of existing models. Only by comparison with actual observations, many of which are made possible only by satellite, can critical improvements be achieved. For these reasons, satellite data have been an important component of the numerous GARP experiments.

GARP has conducted many regional experiments in pursuit of its goals of trying to improve the science of weather forecasting and to understand the physical bases of climate and its fluctuation. Among these regional experiments have been the GARP Atlantic Tropical Experiment (GATE) conducted in the summer of 1974 with one of its goals to assess the effects of small-scale tropical weather systems on the larger scale atmospheric circulation; and the Polar Experiment (POLEX) designed to examine the role of polar regions in global energetics.

The Global Weather Experiment, also known as the First GARP Global Experiment (FGGE) deserves special attention here. Conducted from December 1978 to November 1979, it was one of the most extensive international science experiments in history, involving over 140 countries. The experiment's goal was to try to find the practical limits of weather forecasting and to design an appropriate worldwide coordinated observation system.

United States participants included the Departments of Commerce, Defense, Energy, Interior, Transportation and State; NASA; the National Center for Atmospheric Research (NCAR); the National Science Foundation; the Defense Nuclear Agency; and many academic institutions.

Ten space satellites were involved in the project, including six from the United States 26/ and two polar orbiters from the U.S.S.R.

The scope of the Global Weather Experiment was vast. For a brief period, routine weather observations around the planet were greatly stepped up. Some 50 ships from 22 nations released radiosonde weather balloons daily. Three hundred instrumented buoys were deployed over sparsely reported ocean areas in the southern hemisphere, all monitoring sea and atmospheric conditions for relay to satellites. Commercial and government airplanes returned wind, temperature and pressure data.

At the conclusion of the observing year in November 1979, GARP researchers had collected millions of bits of data from these and other sources. The initial information processing was subdivided among 22 data centers throughout the world. Data were refined for transmission to World Data Centers in the United States and U.S.S.R., and to meteorological research laboratories in Bracknell, England and Princeton, New Jersey. These data are still being refined and applied toward gaining an understanding of 11 months of world weather history, and by extension, an understanding of how the atmosphere behaves.

VI. VALUE OF METEOROLOGICAL SATELLITES

Since TIROS 1 provided the first regular views of the Earth's atmosphere from space in 1960, weather satellites have had a lasting impact not only on the growth of the science of meteorology, but also on the public and private uses of weather data. Satellites show the organization of storms and other atmospheric phenomena with a clarity never approached by aircraft, radiosonde balloons, or any other technology previously available.

Perhaps the most significant contribution of satellites to the science of meteorology has been their continuous supply of global weather data. Before TIROS, there were large gaps in the record of Earth's daily weather, due to the limited number of observation posts in remote regions of the oceans and uninhabited

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26/ TIROS N, Nimbus 7 and NOAA 6 were the polar orbiters. For the experiment, the United States also moved a GOES stationary satellite to fill a gap over the Indian Ocean, in addition to the two maintained over American longitudes.

areas such as deserts. Now we receive daily data from satellites about temperatures and cloud cover over every spot on the globe. Weather forecasts for the West Coast of the United States have particularly improved in the satellite era, since most of that region's weather originates in the Pacific Ocean, once a very sparsely reported area. As a result of satellite coverage, NOAA was able to save money by the retiring of weather station ships in 1975.

This closing of the data gap has been invaluable to meteorologists in their attempt to understand the Earth's constantly mixing atmosphere as a total, global system. The flow of satellite data, when augmented by increasingly better computers and data processing techniques, has helped scientists in their formulation of mathematical models of the atmosphere's behavior, the final goal of which is a workable, accurate Numerical Weather Prediction system. The realization of that goal is still in the future, and will probably involve not only readings from weather satellites—temperature and humidity soundings, cloud data, etc.— but input from conventional weather stations and other types of environmental satellites including the upper atmosphere Explorers and oceanographic sensors. (As an example, ocean wind-velocity measurements from the SEASAT scatterometer instrument have been plugged in for experimental use in numerical weather prediction models.)

Already, though, the impact on forecast accuracy has been great. The National Meteorological Center's pressure and precipitation forecasts reportedly improved by 28 percent (at sea-level) from 1958 to 1972, while skill in forecasting precipitation increased by approximately 13 percent from 1960 to 1971. 27/ George S. Benton, a former president of the American Meteorological Society, testified before a House subcommittee that "today, operational weather forecasts made 48 hours in advance are as accurate as forecasts made 24 hours in advance two decades ago (before the advent of weather satellites)." 28/ As a result of coordinated satellite-dependent research efforts like the Global Weather Experiment and other GARP programs, meteorologists hope to find the means to further extend the range, scope and accuracy of their forecasts.

The users of these forecasts, and of satellite data in general, are widely scattered and many. They include the National Weather Service, Government agencies, the Department of Defense, university and research concerns, foreign meteorological agencies, aviation weather services, private industries, news media, and private citizens equipped with the necessary receiving stations. The National Environmental Satellite Service (NESS) disseminates weather satellite pictures, data and bulletins daily to thousands of users. Archived information and real-time products as well as direct readout transmissions by APT or WEFAX are available. Each day the national Daily Weather picture from the stationary GOES satellites is widely distributed to commercial wire services for TV news and newspapers, as is the Satellite Weather Summary prepared by NESS. There is scarcely a television weather forecaster in the country today who does not

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27/ Brown, H., and E. Fawcett. Use of Numerical Guidance at the National Weather Service's National Meteorological Center. Journal of Applied Meteorology, 554 (11). Nov. 1972. p. 1175-1177.

28/ Benton, George S. Testimony before House Science and Technology Committee, Subcommittee on Natural Resources, Agriculture Research and Environment. Feb. 23, 1982. Unpublished.

use satellite photography and satellite-data-based summaries in preparing the daily local forecasts used by millions of viewers in planning daily activities.

One of the great contributions of weather satellites has been the identification and tracking of hurricanes, tornadoes, tropical storms, severe local thunderstorms, winter storms and other destructive weather phenomena. The study of hurricanes has been especially enhanced by satellite data. From the earliest TIROS pictures scientists have been able to watch the birth of spiralling storms over the ocean, monitor wind circulations to see if the hurricane is intensifying, and to track its path. Since the ESSA operational satellite system came into being in 1966, no tropical storm has gone undetected, according to NESS.

Prior to the use of weather satellites, "surpise" hurricanes swept into inhabited areas, resulting in great loss of life and property. One storm that hit Texas at the turn of the century claimed 5,000 lives alone. Satellite data now lead to early detection of these storms over tropical oceans and to advanced warning, lowering death tolls and property damage. Geosynchronous satellites are particularly important to storm tracking—it was largely through study of ATS 1 satellite photos of hurricane Camille in 1969 that NOAA was able to provide adequate warning to thousands of people living on the Mississippi Gulf Coast. When a hurricane is seen moving toward a given area, careful and precise tracking of the storm's path can also help prevent costly evacuation and protection operations in areas where, as it turns out, they are not needed. Satellites play a major role in keeping the warning areas to a minimum. A 1978 NESS report states that "as a conservative estimate, a reduction of only 5 percent in the coastal warning area would mean an average annual savings of about $2.5 million per year." 29/

Satellite weather bulletins are routinely sent to foreign meteorological agencies whenever a potentially threatening storm is spotted heading their way. As a result of satellite tracking, U.S. Government agencies have also been able to save the cost of airplane reconnaissance of hurricanes.

The prediction of tornadoes has been more difficult for meteorologists, partly because those storms are quicker developing and more short-lived. Still, high resolution visual and enhanced infrared imagery from the GOES satellite, taken at intervals of 15 minutes or less, have enabled forecasters to better pinpoint likely tornado spots.

Floods are another potentially destructive natural occurrence. Estimation of rainfall from GOES infrared cloud imagery and the mapping of snow cover by NOAA polar orbiters to predict spring snowmelts not only aid in flood warning, but also in water supply, irrigation and hydroelectric power management. It has been estimated that the cost ratio between satellite and conventional aerial mapping of snow cover is as much as 200 to 1 in favor of the satellite, and

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29/ Hussey, W. John, and Larry E. Heacock. The Economic Benefits of Environmental Satellites. Washington, D.C., National Environmental Satellite Service. National Oceanic and Atmospheric Administration, Dept. of Commerce, Apr. 1978. p. 22.

that annual savings in mapping the Sierra Nevada basins alone could be as much as $100,000. 30/ Satellite weather information is valuable to commercial and private aviators in many ways. Satellite-dependent forecasts are used as a matter of course by pilots in their pre-flight planning, especially for long distance flights, since the avoidance of major disturbances and storms is an obvious advantage for safe airplane flight. In 1977 the Federal Aviation Administration (FAA) initiated a program whereby air traffic controllers would routinely guide air traffic around severe weather as forecast with the aid of satellite data.

Similarly, a number of Latin American airlines regularly flying tropical routes, including LANCIA (Nicaragua), VARIG (Brazil) and Air Panama, initiated a program in 1977 to use satellite imagery for flight planning. Analysis of satellite weather images has been used to avoid extreme weather in some cases, and to use the winds around intense storm systems to advantage at other times. The analysis has even helped in planning of in-flight meal times, when turbulence is at a minimum.

The Nimbus 7 satellite's Total Ozone Mapping Spectrometer was the key instrument in a 1981 experiment involving NASA, the FAA and the Northwest Airlines to determine ozone levels in the atmosphere. The satellite data are intended to help commercial airlines avoid ozone concentrations, which can cause ear, eye, nose and throat irritation among passengers. Ozone levels are also an aid in determining the exact location of the jet streams that help airplanes save fuel and make better time in flight. Researchers envision a system which would provide the jet stream information directly to air-traffic controllers for improved route mapping.

Another aviation-related experiment was the Aircraft-to-Satellite-Data Relay (ASDAR) program conducted by NASA during the Global Weather Experiment in 1979. Several specially equipped commercial airplanes would transmit data on the weather around them--temperatures, wind speed and direction, etc.--up to synchronous satellites, which were then relayed to NOAA. Other planes could use this information in planning the best and most economical flying and tailwind conditions. The ASDAR experiment was deemed very successful and the World Meteorological Organization (WMO) has plans to make it into an operational system.

Search operations for missing or downed aircraft have also been greatly improved by the use of satellite data. As an example, satellite support of search and rescue missions by the California Civil Air Patrol since 1976 has led to an average decrease of 62 percent in the number of hours flown per mission. Similar savings have been by the Aerospace Rescue and Recovery Service of the U.S. Air Force. 31/

The savings in fuel and time of operation of these search and rescue aircraft can be quantified, whereas the savings of lives as a result of quicker, more efficient rescues cannot.

30/ Ibid., p. 16.

31/ McClain, E. Paul. Environmental Satellites. New York, McGraw Hill Encyclopedia of Environmental Science, 1980.

The shipping industry uses forecasts of weather conditions over the oceans (largely determined by satellite data) in the same way as airlines—to plan safe, trouble-free routes. In addition, NOAA satellite infrared measurements of sea surface temperatures can be used to determine the exact locations of swift-moving currents that constantly change their position. A 1975 experiment conducted jointly by NOAA and the Exxon Corporation led to the estimate that Exxon alone might save $360,000 in fuel costs each year by having tankers hitch rides on the Gulf Stream northbound and avoid it in southern trips. 32/

Polar orbiters also provide valuable data on sea ice conditions, especially in the Arctic regions. Sea-ice observations have helped to plot shipping routes in the Great Lakes region, and have allowed shipping lanes to stay open for longer periods each year, resulting in estimated annual savings of 30 to 60 million dollars. 33/

Sea ice measurements by NOAA satellite AVHRR equipment are used for yet another purpose by offshore oil and gas drillers in Alaska, who monitor the satellite images of ice floes to determine potential danger to rigs.

The U.S. fishing industry saves much fuel and time by using satellite infrared imagery of "thermal fronts" in coastal waters. These fronts—showing water temperature differences at the ocean surface—are valuable tools in predicting where certain commercially valuable fish are going to be. Time spent looking around for fish is thus converted to time spent catching them. Crab fishermen in the Southern Bering Sea, after losing $3 million in 1980 because of ice formations ruining their crab pots, have learned to use satellite data to retrieve the pots before ice forms.

A study published in 1973 by the Space Science and Engineering Center of the University of Wisconsin showed that improved weather information and forecasting could also provide large economic benefits to the agriculture industry, and that improved weather information would have saved crop growers and processors $74 million in 1971. 34/

The greatest gains would be for those growing such crops as citrus fruits, apples, cotton, rice and sugar beets. The Hawaiian sugar cane industry greatly benefits from satellite weather forecasting, since the crop is burned just before harvest, and the burning operations must take place under certain wind and rainfall conditions.

Benefits to the Florida citrus fruit crop are especially well documented. By advising growers of impending frosts, satellite-dependent forecasters have been able to be more precise about the likelihood of freezing weather. Growers can thus limit expensive heating operations only to the times when they are definitely needed. This yields an estimated annual savings potential of $48 million. 35/

32/ Hussey and Heacock, op. cit., p. 7.

33/ Ibid., p. 13.

34/ Ibid.

35/ Ibid., p. 8.

While it is difficult to quantify, it can be said also that the meteorological satellite program has had the indirect result of strengthening international ties, through such programs as the World Weather Watch and the supplying of storm warnings by the United States to foreign countries. In the opinion of George Benton, former president of the American Meteorological Society and past director of the Environmental Research Laboratory:

> Countries all ovar the world interrogate our satellite as it passes overhead, and obtain images which show the distribution of clouds and weather over and near their territory. These images are of vital importance to many developing nations, which have only primitive weather observing systems.
>
> Weather satellites have been one of the major successes of the space age. In addition to the value of the satellites to the meteorological and hydrological services of the United States, the orbiters have contributed substantially to world cooperation and stability. 36/

36/ Benton, op. cit.

2 Air Force Weather Satellites Inoperable 17 Months, Sources Say

By Robert C. Toth

Los Angeles Times

The highly sophisticated, multimillion-dollar satellites launched by the Pentagon to gather weather data critical for U.S. military and intelligence operations have been virtually inoperable for at least 17 months, U.S. military and civilian officials say.

As a result, the Department of Defense has been forced into the position of depending on less-complex civilian satellites and using the same data that goes to the local weatherman.

Officials say the civilian data has become so important that the Air Force has classified key aspects of its meteorological satellite program as secret.

An Air Force public affairs officer, Capt. Ron Rand, said last week that the military weather satellite program is not classified, but he said "the number of defense meteorological satellites in orbit and the percentage of their design capacity at which they are now operating is classified."

Rand said the new classification was imposed about 17 or 18 months ago. Other officials said it went into effect almost two years ago.

The result is that the Air Force refuses to say whether any of its weather satellites are in space and how they are working.

However, sources said that of the two military weather satellites in polar orbit one is spinning uselessly out of control.

On the second satellite, the primary instrument—the imager, which, in effect, takes visible and infrared pictures—has failed, they said.

A third Air Force weather satellite was destroyed when its launch rocket failed, Reagan administration officials said.

Two earlier military weather satellites went into orbit and worked successfully for longer than their design life. The Air Force offered no reason for the recent satellite failures and refused to discuss plans for future launchings.

However, sources said a new weather satellite is expected to be launched in a few months.

The two military weather satellites in polar orbit are almost identical in size and appearance as two civilian satellites also in north-to-south orbits, but the military satellites were designed to take more detailed pictures and collect more information.

One measure of the importance of the two civilian weather satellites to the Pentagon was an official Navy commendation last month to the National Environmental Satellite Service for providing "the only high-quality satellite data available" on the Falkland Islands region during the British-Argentinian war.

Apparently, not even U.S. spy satellites could take pictures as well as the weather spacecraft, possibly because the reconnaissance satellites, whose primary focus is the Soviet Union, do not range as far south or are too high in space when passing over the far southern areas.

Both the civilian and military weather spacecraft are made by RCA Government System Division.

The civilian versions cost $40 million to build and $40 million to launch into their 500-mile-high orbits, Dr. Harold Yates, research director of the civilian agency, said. The Air Force says its combined spacecraft and launching costs total $73 million.

The civilian service operates, in addition to the two satellites in polar orbits, two high altitude satellites that are in geosynchronous, or "stationary," orbits 22,300 miles above the equator. One photographs the Western Hemisphere and the other covers the Eastern Hemisphere every half hour.

Their pictures are commonly shown on TV weather forecasts.

The civilian polar-orbiting satellites are "sun synchronous" so that they can return over the same spot on the equator with the sun at the same angle.

They measure air temperatures at various altitudes, sea water temperature, cloud cover and wind speeds. Their normal scene covers a square 2.5 miles on each side, although they can be adjusted to produce more detailed images of squares 0.6 miles on a side.

The military weather satellites were designed to focus on squares at least one-fourth smaller in area. They were also designed to measure the age and extent of ice coverage, soil moisture, ionospheric data that affects navigation and communication satellites, and other militarily important factors.

These satellites, unlike the civilian ones, were also designed to measure cloud cover over the Soviet Union so that U.S. spy satellites could be told when to take pictures. And their orbits were chosen to provide data at dawn at key, potential battlefield regions such as Europe.

At least five mobile ground stations had been deployed to Air Force bases around the world, and to one Marine Corps facility, to receive data from the military weather satellites that now are not working.

The Reagan administration last year decided that the Landsat program, now run by NASA, will end with the satellites now in orbit unless private industry buys it.

Source: Washington Post, Sept. 27, 1982. p. A2.

Landsat Extension to Rest On Private Sector Support

By Alton K. Marsh

Washington—The Reagan Administration has decided that when the last of two proposed Landsat D satellites fail about 1988, the Earth remote sensing program fails with them unless the private sector has taken over the program by that time.

The current contenders for operation of a civil Earth resources remote sensing capability are:

- Comsat General Corp.—Comsat wants the federal government to sell both meteorological and Earth resources sensing satellites, along with certain related equipment, to the private sector. In turn, Comsat wants a government contract for a guaranteed minimum level of data purchases.
- Itek Corp.—Itek wants to launch a large-format camera on board the space shuttle.
- Terra-Mar, Los Altos, Calif.—Terra-Mar wants to launch a framing camera on a privately built rocket to be constructed by G. C. H. of Sunnyvale, Calif. Terra-Mar has not completed its financing arrangements. President Donn C. Walklet, a marketing consultant, tried to get Comsat to join the Terra-Mar consortium, but Comsat was not interested. He is now trying to attract the interest of oil and mineral companies.
- Hughes Aircraft—Hughes is beginning a review this week, which will take several weeks to a few months, aimed at a decision on whether to offer a proposal. Hughes has written the White House Office of Management and Budget to request that the government separate meteorological and Earth resources sensing issues. The government should not consider them a package, Hughes believes.

Broader Tax Base

Comsat has promised the White House Office of Management and Budget that its proposal would reduce the budget and broaden the tax base. It was primarily the need to reduce the budget and the desire not to lose the investment thus far in Landsat technology that led the Reagan Administration to its current policy of turnover to the private sector.

"We have to hope and pray that the private sector has decided to move in and fill the void by the time the last Landsat dies," an official of the National Oceanic and Atmospheric Administration said. NOAA will operate Landsat D until it fails, and then operate Landsat D Prime after it is launched.

"We are talking frantically with people in the private sector, and there is some interest expressed," he said.

A White House official explained the policy last week, which has been suspected but not spelled out by the Administration since budget figures were announced Mar. 10. In the budget, funding for Landsat D and D Prime was continued, as well as research and development for new sensor technology.

"But the funding in NOAA to purchase follow-on satellites beyond the two NASA research and development satellites was eliminated, with the notion that future satellites beyond those presently budgeted within NASA would depend on the willingness of the private sector to invest," the White House official said.

"The present two satellites will provide coverage, if there's no premature failure, through 1988," he continued.

"If you talk with Itek, which is interested in putting up the large format camera, their concern is that government not compete with them and undercut their market. It would appear, then, at the minimum we will have a large format camera available.

"Other firms appear to be saying that without some kind of effort on the part of the government to reduce the risk, they're not sure it would be prudent for them to invest in this kind of thing.

"What would you expect someone who stands to benefit to say? If somebody's out to buy a car, they aways put on their old clothes," the White House official said.

He said officials in the White House are aware that other nations are planning to enter the remote sensing market. The French plan to launch a remote sensing satellite in 1984.

"There is clear awareness that this is one issue that needs to be dealt with. There are other issues occupying the time of high Administration officials. It's in the queue. "They would like to get to it as soon as possible, preferably before the fall budget process," he said.

The Reagan Administration would like transfer to the private sector of the Earth remote sensing system to take place before 1988, but is aware legislation may be required for that to happen. That legislation is in preparation by the Commerce Dept.

"There are two areas in which legislation may be necessary. One has to do with the transfer of assets. If it were determined that it was possible to transfer this to a private sector owner/operator prior to 1988, like 1984 or so, on the basis that it would be advantageous to the government, the process might involve the transfer of assets. The other area involves provisions necessary to insure compliance with national security needs and foreign policy, including existing treaties," the official said.

Early Stages

He pointed out that the Administration is still in the early stages of its policy on transfer of remote sensing to the private sector.

"It's one thing to have a legislative package that authorizes certain things to be done, and it's another to go through the process that would demonstrate it would be in the best interests of government to do that," the White House official said.

The Commerce Dept. bill was designed to stimulate debate on the best way to transfer the remote sensing program to the private sector. NASA has criticized the bill and has suggested it be redrafted.

Title 1 of the bill, which has not been released to the public, requires the Commerce Dept. to license civil remote sensing. Title 2 allows the secretary of Commerce to award a contract for government purchases of data. This provision insures a potential civil operator a minimum income that can be expected from the government and aids in reducing the financial risks of the venture. Title 3 provides for operation by NOAA of the interim system until the private sector is able to provide the government with the data it needs.

Joint Venture

The bill [illegible] permission to sell, donate or [illegible] Landsat assets owned by the federal government. It also allows the government to enter into a joint venture with individuals or consortiums.

Remote sensing firms that do not win a government contract can appeal to the President as a forum of last resort.

Another feature of the bill would allow the Commerce Dept., if it chooses, to charge realistic user fees for the data while the sensing program is still being operated by the government on an interim basis. In effect, this amounts to a test marketing by the federal government.

Essential to the Reagan policy is the requirement that there be no mishap during launch or early component failure while in service of both Landsat D and D Prime.

The Commerce Dept. bill was to have been announced during joint House-Senate hearings on remote sensing last week, but since the Senate and House have not yet seen the bill, the Commerce Dept. was urged to remove a description of it from testimony.

The main difference between the Carter Administration policy and that of the Reagan Administration is the length of time allowed for turnover of the Landsat system to the private sector. Carter policy was to move toward an eventual turnover, while the Reagan Administration prefers to do it more quickly to reduce the federal budget.

States find themselves caught in the middle of the transfer from federal to private control. Michigan state Republican Rep. Tom Anderson, chairman of the National Conference of State Legislatures, told a joint Senate-House Landsat hearing last week that his organization is concerned that such a significant change in federal policy will not be examined closely enough.

"The space segment of the system has been developed at very high costs, completely from tax dollars paid by the citizens of this nation.

"State and local governments would be hard-pressed to afford data products that are priced to recover such capital investments, and the development of a broad-based market would certainly be stunted," Anderson said.

Two other areas of concern to the states are:

- Technology transfer.
- Data continuity.

"Technology transfer remains the Number 1 issue of concern to the states," Anderson said.

"Given the $1-billion investment in the Landsat program, we believe it would be short-sighted not to spend the relatively little extra required to assure that the technology is readily available to the states." ☐

Aviation Week & Space Technology, July 27, 1981

DATE: September 3, 1982

TO: U.S. Department of Commerce
Office of Field Operations
Commerce Business Daily Section
PO Box 5999
Chicago, Illinois 60680

Transmittal No: 1298

US Department of Commerce, NOAA/National Earth Satellite Service, Washington, D.C. 20233

M--CIVIL OPERATIONAL REMOTE SENSING FROM SPACE

The Secretary of Commerce is examining two issues with regard to the nation's civil remote sensing satellites:

1. What is the best mechanism to implement the current policy of transfer of civil land remote sensing systems (LANDSAT) to the private sector as soon as possible?
2. Should the Administration consider simultaneously private sector transfer of both civil weather and land remote sensing systems? (At this time, Administration policy is that civil weather satellite systems should remain in the Government.)

To assist in the process, the Secretary is requesting that the views of private industry be obtained. These views will be analyzed by the Administration and its advisory committee. This committee includes private sector representatives. Based in part on the results of this process, it is planned that a formal Request for Proposals will be prepared.

Private sector representatives are invited to present their views and expressions of interest on ownership and/or operation of the land and weather satellites and the likelihood of Government savings in either mode and the mechanisms for transfer of these systems to the private sector. All or part of the information provided will be treated as confidential to the extent permitted by law. Offerors should clearly mark those pages of their response that contain proprietary information. The response may include both, either, or any part of either system. The desired information includes:

1. A statement of the recommendations and rationale for transfer of all or any part of these satellite systems.
2. A discussion of the technical and business aspects of any proposed transfer, with particular emphasis on continuity of service and the cost savings to the Government.
3. A description of the terms and conditions that are necessary for a successful transfer. This should include, but not necessarily be limited to:
    a. Any desirable or undesirable Government regulation.
    b. Any need for legislation.
    c. Use of Government facilities, ground stations, and equipment.
    d. Services to be provided to the Government and public.
    e. Time frame in which transfer is considered feasible.
4. A description of the proposed remote sensing system and its capabilities (area of coverage, spatial resolution, sensor frequency bands, interval between repeat coverages of a ground site, etc.), including plans regarding direct transmission of data to foreign ground stations and distribution of data to international and domestic customers.

5. Anticipated evolution of new or improved sensing capabilities under the proposed transfer, and recommendations for a means to assure that evolution in any contractual or regulatory vehicle.
6. Response to foreign competition and its effects.
7. Potential for commercial international joint ventures in remote sensing and their implications in the areas of export control and national security.
8. If transfer is recommended for all or part of the civil weather satellite systems, information should be supplied on:
    a. Assumption of command and control by the Department of Defense in emergencies.
    b. Effect of providing selected priority service to defense needs when required.
    c. Feasibility and savings associated with combining weather and land satellite functions (space and/or ground segment), and recommendation.
    d. Use of existing Government facilities, ground stations, and equipment inventory.
    e. Use of existing industry facilities, ground stations, and equipment inventory.
    f. Proposed criteria for launching replacement satellites and selection of orbital parameters.
    g. Weather satellite service costs under the proposed transfer to permit comparisons with current costs.

h. A statement of the pricing and data distribution practice (domestically and internationally) that would be employed for weather data.

i. Intended approach to the evolution of sensor systems still in an R&D stage, such as the VAS on the geostationary weather satellites.

j. Approach to be used with foreign-supplied instruments, such as the ARGOS and SSU on the polar-orbiting weather satellites.

k. Approach to respond to the National Weather Service priorities for severe storm data (National Severe Storms Forecast Center in Kansas City and National Hurricane Center in Miami) and for major forecast operations (National Meteorological Center in Camp Springs, Maryland).

A briefing package on the civil remote sensing satellites has been prepared and interested parties may obtain it from Mr. Robert L. Birchfield, Director of Resources and Management Services, National Earth Satellite Service/NOAA, Washington, D.C. 20233. His telephone number is (301) 763-2690. A conference will be held for industry at 9:30 a.m. on September 17, 1982, in Room 4830 of the Herbert C. Hoover Building (formerly the Commerce Building), 14th & Constitution Avenue, N.W., Washington, D.C. Firms planning to attend the conference should notify Mr. Robert L. Birchfield of their intent and the number of persons attending.

Offerors should submit 25 copies of their response to Dr. John H. McElroy, Assistant Administrator for Satellites, National

Earth Satellite Service/NOAA, Washington, D.C. 20233, no later than October 22, 1982. Dr. McElroy's phone number is (301) 763-5240. This request for information does not commit the Government to pay any costs incurred for the preparation of a response.

Queries may be addressed to either of the above.

This request for information is not subject to the normal clearance functions required in Sec. 3506(c)(5) of P.L. 96-511 (Paperwork Reduction Act).

Ralph P. Conlin
Contracting Officer

DATE:

TO: U.S. Department of Commerce
Office of Field Operations
Commerce Business Daily Section
PO Box 5999
Chicago, Illinois 60680

Transmittal No:_______________

US Department of Commerce, NOAA/National Earth Satellite Service, Washington, D.C. 20233

M--CIVIL OPERATIONAL REMOTE SENSING FROM SPACE

The notice published September 10, 1982, is amended to include the following Preamble:

> It is the policy of this Administration to seek commercialization of Governmental activities which are not uniquely Governmental in nature since private enterprise is the primary source of our national economic strength.
>
> The United States Government currently operates civil satellite systems to collect and disseminate remotely sensed weather and land satellite data. This data is used by numerous departments and agencies to perform Government services and is used by the private sector to extract information valuable in that sector. Civil satellite remote sensing is an activity which has a potential for substantially greater commercialization. Private entities have expressed interest in providing the remotely sensed satellite data that is needed by the Government and non-Government users on a commercial basis. The Land Remote Sensing Advisory Committee is currently soliciting other expressions of interest from the private sector for ownership and/or operation.

While it is the current policy of the Administration to seek prompt commercialization of land satellite remote sensing and to retain the civil weather satellites in the Government, that policy will be reexamined if commercialization of both systems is shown to produce cost savings to Federal agencies.

A conference for industry will be held at 9:30 a.m. on September 17, 1982, in Room 4830 of the Herbert C. Hoover Building (formerly the Commerce Building), 14th & Constitution Avenue, N.W., Washington, D.C. Firms planning to attend the conference should notify Mr. Robert L. Birchfield of their intent and the number of persons attending.

This request for information is not subject to the normal clearance functions required in Sec. 3506(c)(5) of P.L. 96-511 (Paperwork Reduction Act).

Ralph P. Conlin
Contracting Officer

AMERICAN SCIENCE AND TECHNOLOGY CORPORATION
4401 EAST/WEST HIGHWAY, SUITE 501
BETHESDA, MARYLAND 20814
(301) 656-0434

March 28, 1983

Ms. Pat Humphlett
Policy Analyst
Division of Science Policy Research
Congressional Research Service
James Madison Building
Washington, D.C. 20540

Dear Ms. Humphlett:

Thank you for your inquiry concerning the American Science and Technology Corporation's response to the Commerce Business Daily Request for Information (September 10, 1982), which solicited input from potential private sector participants on commercialization of the civilian land and/or weather satellites. A copy of the Background and Rationale sections of our submission are attached for inclusion in the "reader" you are preparing for use by the House Science and Technology Committee, as well as a copy of our April 7, 1982, letter to Secretary Baldrige. We are unable to release the entire submission due to the proprietary nature of the information contained in the remaining sections.

Since this submission, the American Science and Technology Corporation has formed a joint venture with Space Services Inc. of Houston, Texas. Materials describing the specifics of the AS&T/SSI "AEROS Program" are available but have not been submitted formally to the Department of Commerce. Current AEROS Program plans call for a three satellite system, with the first launch scheduled in 1985. The Program is designed to provide continuity of Landsat data by flying two side-viewing sensors, each with a 160km swath width, providing six visible bands at 80 meter resolution and two visible bands at 40 meter resolution. Stereoscopic data will be available at 40 meters. The use of solid-state technology in these sensors results in an estimated useful life of 5 years for these satellites. The launch of the second AEROS satellite in 1987 will allow for 6- and 12-day repeat coverage. Current plans call for the second satellite to provide four visible and two near-infrared bands at 40 meter resolution and two visible bands at 20 meter resolution. Subsequent AEROS satellites will fly sensors with bands and resolution increases based on market demand, but we anticipate operating a three satellite system with 6-day repeat coverage by 1989.

If you would like further information about the AEROS Program, please feel free to contact Ms. Kate Bonner, Director, Government Relations, at 646-1021.

Again, thank you for your interest in our program.

Sincerely,

Diana H. Josephson

Diana H. Josephson
President

DHJ/ams
Attachments

RESPONSE
TO THE
REQUEST FOR INFORMATION
WITH RESPECT TO
CIVIL OPERATIONAL REMOTE SENSING
FROM SPACE

Commerce Business Daily Announcement
September 10, 1982

American Science and Technology Corporation
4401 East-West Highway, Suite 501
Bethesda, MD 20814
Tel: (301) 656-0434

October 22, 1982

Proprietary

Background

The American Science and Technology Corporation (AS&T) plans to launch a series of four low-cost, high-technology, earth remote sensing satellites, starting in 1985, that will comprise the Advanced Earth Resources Observational System (AEROS). The first of these satellites will provide earth resources observations from a 185 kilometer swath at 80, and possibly 40, meter resolution in the familiar Multi-Spectral Scanner (MSS) format. Progress in its sensor design may also permit it to provide Thematic Mapper (TM)-type data in the two near-infrared bands at 80, and possibly 40, meter resolution. The second satellite will provide, in addition, earth resources observations in several other TM and Coastal Zone Color Scanner (CZCS) bands at 80 and 40, and possibly 20, meter resolution. These data will be transmitted by direct downlink to any Landsat ground station for a proposed annual access fee of no more than $500,000 per sensor.

Like Landsats 1, 2 and 3, the AEROS satellites will fly in a sun-synchronous, 80° inclined orbit at an altitude of 917 kilometers and will cross the equator at approximately 0930 hours. They will have an estimated useful life of 5 years. Ultimately, in response to market demand, AEROS could provide repeat coverage every 4-5 days.

AS&T's initial sensor design is nearing completion and discussions are underway with possible sensor and spacecraft manufacturers. AS&T plans to use the Conestoga 200 launch vehicle currently under development by Space Services, Inc., of Houston, Texas.

On April 7, 1982, AS&T wrote to the Honorable Malcolm Baldrige, Secretary of Commerce, in his capacity as Chairman of the Cabinet Council on Commerce and Trade, to apprise him of its interest in assuming operational command and control of the two Landsat D satellites from the U.S. Government, and in integrating these satellites and its own satellites into the first U.S. commercial operational earth resources observational system. A copy of that letter is attached as Exhibit A. AS&T representatives subsequently reviewed this proposal with Dr. Victor H. Reis, Assistant Director, Office of Science and Technology Policy, Dr. Annelise Anderson, Associate Director for Economics and Government, Office of Management and Budget, Dr. John V. Byrne, NOAA Administrator, and James M. Beggs, NASA Administrator, as well as key Congressional staff. AS&T's interest in assuming operational command and control of the two Landsat D satellites stems from its long-range goal of providing low-cost, high-quality, earth resources observations to users worldwide, during the 1980's and beyond.

Specifically, AS&T proposes to assume operational command and control of Landsat 4 as soon as possible and of Landsat D' after satisfactory launch and checkout in orbit. In addition, it proposes to assume the operational responsibility and the concomitant financial burden for that portion of the Landsat D ground station at the Goddard Space Flight Center (GSFC) that is associated with command and control of these spacecraft. AS&T will market the resultant downlink data to Landsat ground stations worldwide, including the Landsat D ground station at GSFC. In turn, AS&T will receive the revenues derived from the sale of these data to these ground stations. AS&T will integrate Landsat 4 and Landsat D' and the AEROS operational satellites into a single, multi-satellite system so as to provide a smooth transition from the U.S. Government's R&D system to the first U.S. commercial operational system.

AS&T does not propose to own either Landsat 4 and Landsat D' or that portion of the Landsat D ground station that is associated with command and control of the spacecraft, nor does it propose to own or manage either the data processing segment of the Landsat D ground station or the Landsat D activities at the EROS Data Center. In addition, since the revenues from the Landsat ground stations will not support these costs, it does not propose to assume financial responsibility for the storage and launch of Landsat D' or to use the Tracking Data and Relay Satellite System (TDRSS). However, AS&T will provide Landsat D data via TDRSS if the operator of the data processing segment of the Landsat D ground station at GSFC assumes the TDRSS costs.

The following response to the Request for Information with respect to Civil Operational Remote Sensing from Space published in the Commerce Business Daily on September 10, 1982, is in the format established in the Request for Information.

I. Rationale for Proposal

AS&T believes that it is imperative that the United States maintain its leadership in the provision of earth resources observations from space. AS&T's primary business purpose is to develop its own satellite system, one that provides continuity of Landsat-type data, but at a sufficiently low cost that the revenue from ground station access fees can provide an attractive return on investment. As set forth above, AS&T will integrate Landsat 4 and Landsat D' with its own AEROS satellites into a single, multi-satellite, commercial U.S. system that will provide data continuity as long as market demand continues. In addition, AS&T will improve the capabilities of its satellites by the introduction of additional spectral bands, improved resolution, and, possibly, tape recorders as rapidly as technological advances and market demand permit.

In order for the United States to maintain its leadership in this high technology arena, not only must continuity of data be ensured but data must also be marketed vigorously in light of the plans of other countries, such as France, India, and Japan, to launch earth resources observations satellites during the 1980's. Unlike the French Government, which is marketing its SPOT data vigorously, the U.S. Government is precluded from marketing. Transfer of operational command and control of Landsat 4 to AS&T will enable it to play this key private sector role at the earliest possible time.

Earth resources observations data are a critical information tool in the more than 100 countries now operating remote sensing programs worldwide. By 1985, some twenty countries expect to have Landsat ground stations in operation. Other countries will also make this investment later in the 1980's. AS&T and its sister corporation, AEROS Data Corporation (AEROSdata), have the existing contacts in these countries that will enable the United States to remain the predominant force in the international market for earth resources observations data.

Finally, AS&T seriously questions whether the Landsat 4 and Landsat D' revenue streams will support the operational cost of the entire Landsat D ground facility at GSFC, as well as the Landsat D portion of the EROS Data Center's operational costs. However, AS&T believes that the revenue stream from the annual access fees paid by Landsat ground stations can support the operational costs of that portion of the Landsat D ground station at GSFC that is associated with command and control of these satellites, as well as an aggressive marketing program for the data from Landsat 4 and Landsat D' and a reasonable profit. AS&T will return any revenues over and above these costs to the U.S. Government.

Proprietary

EXHIBIT A

AMERICAN SCIENCE & TECHNOLOGY CORPORATION
Suite 501
4041 East-West Highway
Bethesda, Maryland 20814
U.S.A.

April 7, 1982

Honorable Malcolm Baldrige
Secretary of Commerce
Washington, D.C. 20530

Dear Mr. Secretary:

I am writing to you, as Chairman of the Cabinet Council on Commerce and Trade, to apprise you of our interest in assuming command and control of the Landsat D and D' satellites from the U.S. Government by January 31, 1983.

Our company, American Science and Technology Corporation (ASTECH), working in conjunction with Space Services, Inc., plans to launch a series of four, low cost, high technology, land remote sensing satellites, starting in 1984. The first of these satellites will provide Multi-Spectral Scanner-type data at a 60 x 80 meter resolution. The second and subsequent satellites will, in addition, provide data in most of the Thematic Mapper and Coastal Zone Color Scanner bands, also at a 60 x 80 meter resolution.

Our interest in assuming command and control of the Landsat D and D' satellites stems from our long-range goal of providing low cost, high quality, earth resources observations to users world wide, during the 1980s and beyond. The specifics of our proposal and its advantages to the U.S. Government are contained in the attached material. In sum, we do not propose to buy the Landsat D and D' satellites, nor to assume financial responsibility for the storage and subsequent launch of Landsat D'. Rather we propose to assume control of Landsats D and D' after satisfactory launch and checkout in orbit, and to market the resultant downlink data. We will integrate Landsats D and D' into our system of operational satellites so as to provide a smooth transition from a U.S. Government R&D system to the first U.S. commercial operational system, in accordance with the policies of the current Administration.

I would appreciate the opportunity to discuss our proposal with you.

Sincerely,

Norman H. MacLeod

Dr. Norman H. MacLeod
President

cc: Hon. Alexander M. Haig, Jr, Secretary of State
Hon. Casper W. Weinberger, Secretary of Defense
Hon. James G. Watt, Secretary of the Interior
Hon. John R. Block, Secretary of Agriculture
Hon. William J. Casey, Director, Central Intelligence Agency
Hon. James M. Beggs, Administrator, National Aeronautics and Space Administration
Hon. John V. Byrne, Administrator, NOAA
Hon. David S. Stockman, Director, OMB
Hon. George A. Keyworth, III, Director, OSTP
Senator Bob Packwood
Senator Harrison Schmitt
Senator Howard Cannon
Senator Charles McC. Mathias, Jr.
Congressman Don Fuqua
Congressman Ronnie Flippo
Congressman Larry Winn, Jr.

Proprietary

April 7, 1982

COMMERCIALIZATION OF U.S. LAND REMOTE SENSING FROM SPACE

The American Science and Technology Corporation (ASTECH), working in conjunction with Space Services, Inc., plans to launch a series of four, low cost, high technology, land remote sensing satellites, starting in 1984. The first of these satellites will provide earth resources observations at a 60 x 80 meter resolution in the familiar Multi-Spectral Scanner (MSS) format. The second and subsequent satellites will provide, in addition, earth resources observations in most of the Thematic Mapper (TM) and Coastal Zone Color Scanner (CZCS) bands, also at a 60 x 80 meter resolution. These data will be available by direct downlink to any Landsat ground station. The AEROS series will fly at an altitude of 917 kilometers, will cross the Equator at approximately 0930 hours, and ultimately could provide repeat coverage every 4-5 days. Cost savings resulting from the use of proven solid-state and other state-of-the-art technologies will enable ASTECH to provide earth resources observations in the MSS format, and later in both the TM and CZCS formats, at rates considerably below those to be charged for similar data from the Landsat D series of satellites.

ASTECH proposes to assume command and control of the Landsat D and D' satellites from the U.S. Government, and to market the resultant downlink data. ASTECH will integrate Landsats D and D' into its system of operational satellites so as to provide a smooth transition from a U.S. Government R&D system to the first U.S. commercial operational system, in accordance with the policies of the current Administration.

Proprietary

ASTECH'S Proposal

ASTECH proposes to assume control of Landsats D and D' as follows:

- The U.S. Government will launch Landsat D this summer as planned. ASTECH will assume command and control of Landsat D on January 31, 1983, after satisfactory system check-out in orbit. ASTECH also will assume responsibility for the Landsat D command and control facility at the Goddard Space Flight Center (GSFC).

- Initially, ASTECH will operate the MSS sensor only, except for non-concurrent TM tests over the eastern United States. ASTECH will provide MSS downlink data to Landsat ground station operators, including the Landsat D ground station at GSFC. ASTECH also will provide NASA with TM downlink data via the transportable ground station at GSFC.

- Upon satisfactory check-out in orbit of AEROS-A in 1984, ASTECH will provide MSS downlink data from both AEROS A and Landsat D. TM downlink data for R&D purposes will be provided to NASA on a non-concurrent basis until the TM ground station at GSFC is operational. At that time, ASTECH will also provide TM downlink data to Landsat ground station operators.

- The U.S. Government will launch Landsat D' as planned. ASTECH will assume command and control of Landsat D' after satisfactory system check-out in orbit. ASTECH will provide TM downlink data to Landsat ground station operators. ASTECH reserves the right to withdraw from any agreement to assume command and control of Landsat D' if the market for Landsat D' downlink data is insufficient to cover its command and control costs, plus a reasonable profit.

- ASTECH will assume responsibility for the U.S. Government's contracts to supply Landsat D MSS and TM downlink data to current and future foreign and domestic ground stations. ASTECH will be free to develop and enter into new contracts with private sector, national and international entities, both within and without the United States, for the delivery of downlinked MSS and TM data from both the Landsat D and AEROS satellites.

- The U.S. Government will transfer its frequency allocations for the Landsat D satellites to ASTECH for the purpose of integrating Landsats D and D' into ASTECH's AEROS satellite system.

- ASTECH will distribute downlink data from Landsats D and D', as well as its AEROS satellites, in the widest practicable manner.

Advantages to the U.S. Government

- Commercialization of land remote sensing from space will be achieved in accordance with Administration policies.

- The first U.S. commercial land remote sensing satellite service will be introduced in January, 1983, fully eighteen months before the launch of the French SPOT satellite.

- Landsat D MSS and TM data will be available to users as projected, with additonal MSS, TM and CZCS-type data becoming available, starting in 1984.

- NASA's R&D program to maintain U.S. technological leadership in land remote sensing from space will be supported.

- No Federal resources will be required over and above those already identified.

- No guaranteed data purchase contract from the U.S. Government will be required.

- ASTECH will provide data continuity to users through the 1980s and beyond.

Autometric
INCORPORATED

5205 LEESBURG PIKE, SUITE 1308/SKYLINE 1, FALLS CHURCH, VIRGINIA 22041
703-998-7606

20 October 1982

Dr. John H. McElroy
Assistant Administrator for Satellites
National Earth Satellite Service/NOAA
Washington, D.C. 20233

Dear Dr. McElroy:

Autometric, Inc. has been following with great interest the desire of the Administration and the plans of NOAA for commercialization of the civil space remote sensing systems. Although we favor the move, believing it to be in the public interest, we cannot help but think that the plans for imminent transfer are still somewhat premature. Specifically, we believe that industry has been placed in the position of bidding on an entity -- the Landsat/TM system — the value of which is relatively unknown.

As you know, at the present time, the commercial value of the Landsat/TM system has been essentially extrapolated from the value of the Landsat/MSS system as it exists in a non - competitive market. This is unrealistic, because the moment that serious competition arrives upon the scene, this value calculation becomes a financial fiction. Thus far, we seem to be acting as if we did not know that in about two years time we will be facing competition from the SPOT satellite and, judging from its design objectives, the SPOT/HRV will be serious competition indeed. (The commonly heard disclaimer that Landsat and SPOT are complementary, not competing, systems is as yet unfounded.)

What this means is that, until we have a clear, empirically defined idea as to the capability of Thematic Mapper imagery vis-a-vis the capability of SPOT/HRV imagery, we will have no basis upon which to postulate the value that a heretofore monopolistic Landsat/TM system will have in a competitive, free-market milieu.

It is also apparent that any substantial miscalculation of the true market value of the Landsat/TM system could cause severe economic problems for any commercial firm that takes over the Landsat program, since it is quite possible (although by no means certain) that the SPOT will have a technological superiority sufficient to devalue the Landsat/TM product line to a point at which it is no longer profitable. As you also well know, consideration of such a miscalculation raises the specter of a bail-out or government buy-back, a situation that no one wants, from which no one benefits, and from which none of the concerned parties can escape without profound embarrassment.

This is, admittedly, a worst-case scenario, but although it is potentially serious, it is also preventable. By way of prevention, Autometric, Inc. would like to offer for your review the attached proposal precis responding to the announcement in the September 10, 1982 issue of the Commerce Business Daily, item 6 -- "Response to Foreign Competition and its Effects." This proposal describes a methodology for quantitatively evaluating and intercomparing the capabilities of TM imagery, simulated SPOT imagery (which, we understand, will be available over sites in the U.S. early in the summer of 1983), and simulated photography from the Large Format Camera, which may begin to complicate the competitive picture following its STS flight in the autumn of 1983.

The proposed effort closely parallels a similar investigation of remote sensor capability successfully completed by Autometric for the U.S. Geological Survey in December of 1981. This highly successful investigation used a computer-assisted geographic information system for the mensuration, synthesis, and intercomparison of the geologic information content of real- and synthetic-aperture side-looking radar systems, color aerial photos, standard Landsat MSS imagery, and digitally enhanced MSS imagery. The results provided a basis for making cost/benefit comparisons among the sensor systems, the same kind of cost/benefit comparisons that the user community will be making in respect to their purchases of TM, SPOT, or LFC imagery. (See enclosed report and information on Autometric's geographic information system.)

In keeping with the CBD announcement's request for suggestions, the attached proposal is submitted in the form of a precis. If you are interested in receiving a more detailed account, a complete technical and cost proposal can readily be prepared. Also, although our proposal has focussed on the intercomparison of geologic information, we could readily expand this to include other user information if NOAA so desires.

Yours truly,

Andrew Blache Jr.

Andrew Blache, Jr. Ph.D.
Vice President
Imagery Exploitatio Division

AB/mc
Enclosures:

Technical Proposal

A QUANTITATIVE EVALUATION OF THE
LANDSAT/TM,THE SPOT/HRV, AND
THE LARGE FORMAT CAMERA

Autometric

20 October

Technical Proposal

A QUANTITATIVE EVALUATION OF THE LANDSAT/TM,THE SPOT/HRV, AND THE LARGE FORMAT CAMERA

Submitted to:

National Earth Satellite Service
National Oceanic and Atmospheric Administration
Washington, D.C. 20233

Prepared by:

Autometric, Incorporated
5205 Leesburg Pike
Suite 1308/Skyline 1
Falls Church, Virginia 22041

A QUANTITATIVE EVALUATION OF THE LANDSAT/TM, THE SPOT/HRV AND THE LARGE FORMAT CAMERA

1. INTRODUCTION

In order to ascertain the potential market value of LANDSAT Thematic Mapper imagery in a competitive international market, it will be necessary to demonstrate its performance as compared with the performance of the up-coming SPOT system scheduled to be launched by CNES in October, 1984. In addition, since the competitive situation may well become complicated by the advent of the Large Format Camera, a mutual intercomparison of the capabilities of all three systems is necessary. Figures of merit alone, no matter how compelling, provide but a small basis for evaluating the actual performance of a sensor system.* However, a quantitative comparison of the observed information content of LANDSAT/TM imagery with the information content of simulated SPOT/HRV imagery and with imagery from the Large Format Camera, would contribute data necessary for a realistic appraisal of the potential value of the civil satellite remote sensing system to a private corporation.

At this writing, investigators are evaluating TM imagery, and, concurrently, CNES is sponsoring evaluations of simulated SPOT imagery over several European sites, with plans to fly U.S. sites in June-July of 1983. However, there appear to be no plans for a comparative evaluation of the two data sets over a common site.

2. OBJECTIVES

The principal objective of the proposed investigation is to demonstrate, quantitatively, the amount of geologic information that can be produced through an analysis and interpretation of TM imagery and to compare this with the amount of the same kind of information that can be extracted from simulated SPOT/HRV imagery and from simulated Large Format Camera imagery covering the same area. This will be achieved by interpreting the imagery, digitizing the interpretation results, and analyzing the digital data by means of a computer-assisted geographic information system (AUTOGIS), which will be used to measure, synthesize, and intercompare the extracted information and which will display the results in tabular and map format.

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*Pascucci, Smith, and Pearson, 1982 for example, have demonstrated the marked superiority of a real-aperature SLAR system having a resolution of 35 X 150 meters over LANDSAT MSS imagery in the detection of geologic structure.

3. SCOPE AND METHODOLOGY

3.1 TASK 1 — Imagery Acquisition

The following imagery would be acquired by NOAA. Each type of imagery should cover at least four of the sites that will be selected by CNES for SPOT evaluation. Each of these sites will cover an area in the U.S. of approximately 10 by 16 kilometers.

- Thematic Mapper Imagery — in single and multiple bands to be determined in consultation with JPL scientists. One band, however, should be the thermal infrared.
- Simulated SPOT/HRV Imagery — This will be available over 20 U.S. sites in spring or summer of 1983.
- High Altitude Photography flown and degraded so as to simulate the resolution and other photo characteristics that theoretically will be obtained by LFC space photography.

Autometric, Inc. would assist NOAA in the mission planning and in the imagery acquisition task.

3.2 TASK 2 — Imagery Analysis and Interpretation

Geologic structure has been selected as the analytical and interpretational theme of the investigation since it is one of the products in greatest demand by the user community, and because it is relatively unambiguous and lends itself well to quantitative analysis.

Each set of imagery will be interpreted for evidence of geologic structure by at least two experienced remote sensing geologists. The interpretation of each geologist will then be examined by the other for quality control and, finally, the two interpretations will be combined to form a single interpretation containing all of the information mutually agreed upon by both geologists.

3.3 TASK 3 — Digitization of Results

All of the geological data produced in Task 3.2 will be digitized and entered into the data base of an automated geographic information system that will measure, synthesize, and intercompare the geologic information extracted from the TM, the simulated HRV, and the simulated LFC imagery. (The operations of the information system — Autometric's AUTOGIS — are described in Task 4, below.)

3.4 Task 4 — Evaluation of Results

Using the AUTOGIS geographic information system, the digitized geological information from the TM, the simulated HRV, and the simulated LFC imagery will be measured, synthesized and intercompared. The numerical results of these operations, consisting of the number and length of geological structural features, will be printed out in tabular form on an electrostatic TEKTRONIX printer. (A facsimile of this kind of data presentation is shown in Table I.) The positional results, consisting of the location of such geologic features as faults, fractures, fold axes, etc., will be plotted out in map form by a computer-driven CALCOMP plotter. Finally, bar graphs will be prepared showing the absolute and relative geologic information content of each of the sensor systems. (An example of these bar charts is shown in Figure 1.) It is important to note that the graphs in Figure 1 show three important aspects of the results, viz: 1) the total information content of each sensor sytem; 2) the information that was detected in common by two or more of the sensors; and 3) the information that was detected uniquely by each sensor alone. This third aspect of the results — the unique detection of information — is highly important. It means that, even if sensor A is markedly superior to sensor B, sensor B may still be commercially feasible if it supplies the user with a significant amount of information that he cannot get from sensor A. For example, the first bar graph in Figure 1 (top of the page) shows the relative information content of standard, off-the-shelf

SUBJECT	LENGHT (KM)	FREQUENCY	PERCENT OF TOTAL LENGTH
1. Probable Faults or Fractures	43.07	26	2.85
2. Possible Faults or Fractures	885.86	233	58.63
3. Synclinal Axes	303.87	9	20.11
4. Anticlinal Axes	278.20	7	18.41
TOTAL	1511.00	275	100.00

TABLE 1

Facsimile of AUTOGIS Tabular Printout

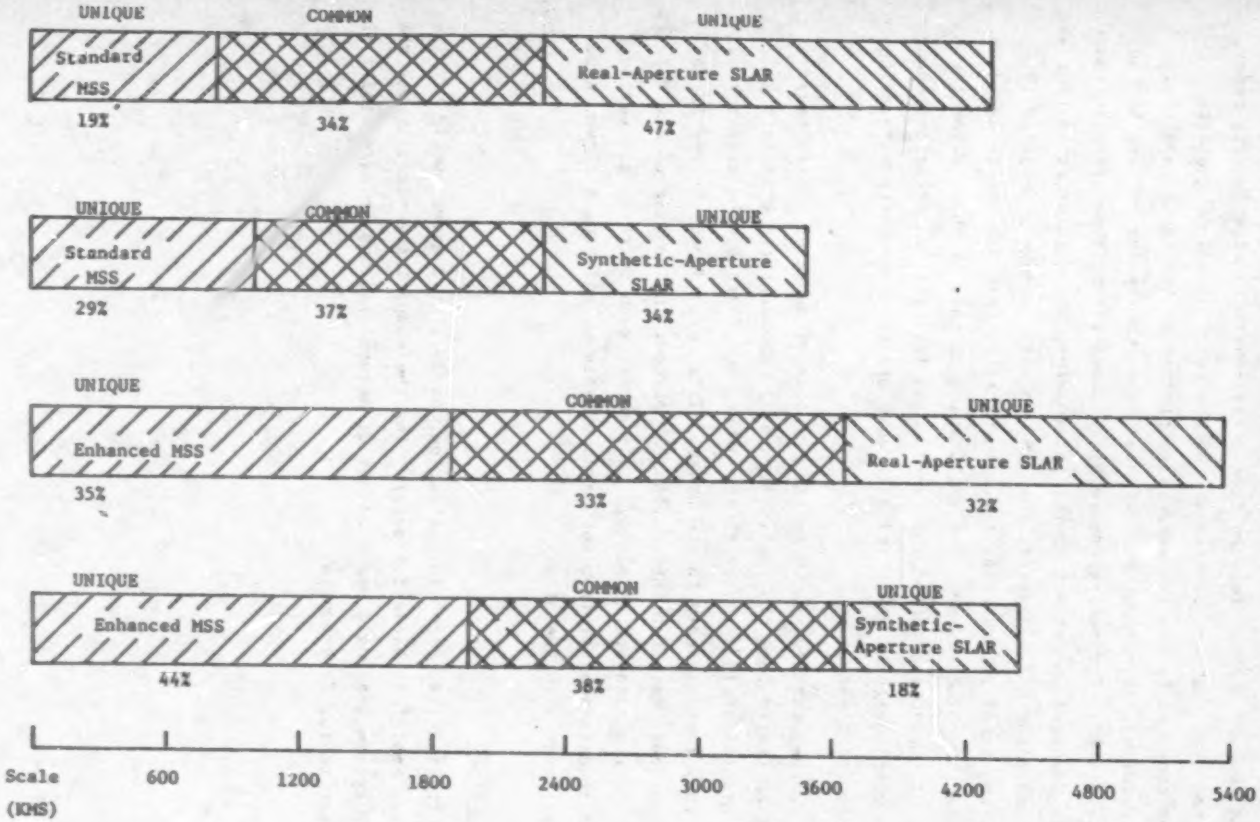

FIGURE 1 -- Bar Graphs Illustrating Total, Common, and Unique Information Content of Sensors

LANDSAT/MSS imagery and the imagery from a real-aperture side-looking radar, both obtained over the same test area. Of the total amount of geologic information detected by the two sensors (expressed as the total length of geologic features), 26 percent was detected in common by the MSS and by the real-aperture SLAR. The real-aperture SLAR proved markedly superior in that it uniquely detected 55 percent of the information, i.e., information that was not detected by the MSS. However, the MSS, in turn, uniquely detected 19 percent of the total information, i.e., information that was not detected by the real-aperture SLAR system. The implication of this is that, depending on the amount of uniquely detected information and its cost, an inferior sensor system may continue to be competitive because of its complementary relation with the competing sensor.

Another example, shown in the relation of enhanced MSS to real-aperture SLAR (third from the top in Figure 1), demonstrates that neither sensor is significantly superior to the other, and that, by the same token, each is highly complementary to the other. This is evidenced by the large amount of uniquely detected information (34 percent in the case of the MSS and 38 percent in the case of the SLAR). In a market such as this, any serious user would require imagery from both sensor systems, and thus each would be fully competitive with the other.

4. RESULTS

The results of the investigation, as described above, would provide a realistic, empirical basis for determining the competitive viability of the LANDSAT/TM system and would serve as one of several factors in determining the price structure for TM products.

EarthStar

COMMERCIALIZATION
of
CIVIL REMOTE
SENSING

VOLUME I
RESPONSE TO REQUEST FOR INFORMATION

COMMUNICATIONS SATELLITE CORPORATION
COMSAT

COMMERCIALIZATION
OF
CIVIL REMOTE SENSING

A Response to the Invitation of the Secretary of Commerce to Present Views and Expressions of Interest on Ownership and/or Operation of Civil Weather and Land Satellite Systems.

Communications Satellite Corporation
(COMSAT)

(October 22, 1982)

SUMMARY

The Communications Satellite Corporation (COMSAT) has examined the technical, financial and managerial aspects of commercializing the Government's civil weather and land remote sensing satellite systems. The transfer of these systems to the private sector and development of a modern, efficient, integrated system are technically feasible. However, we believe the successful development of a commercial system and the realization of significant cost reductions to the Government are possible only if both weather and land systems are transferred and combined. A reexamination of the Administration's policy concerning the civil weather satellites reveals, in our opinion, that there are no issues which preclude commercialization of the weather systems and that a policy to transfer those systems to the private sector would be consistent with the President's economic policy, the Government's commercialization policy enunciated in OMB Circular A-76, and the President's space policy.

COMSAT recommends that the best mechanism to implement a transfer as soon as possible would be for the Administration to adopt a plan of commercialization to be submitted to Congress with implementing legislation that designates the entity to undertake the commercialization of both weather and land systems. Implementing legislation should be passed in 1983 so that transfer could begin in January 1984.

COMSAT is prepared to accept the responsibility for developing a commercial remote sensing system and to assume the technical and managerial risks if both weather and land systems are transferred, legislation is passed in 1983 designating COMSAT to undertake this reponsibility, and a long term contract to supply data to the Government is executed which provides the necessary financial foundation for a commercial operation.

INTRODUCTION

In announcements appearing in Commerce Business Daily of September 10, 1982 and September 15, 1982, the Secretary of Commerce (Secretary) solicited views and expressions of interest from the private sector on ownership and/or operation of the land and weather satellites, the likelihood of Government savings in either mode, and the best mechanism for transfer of these systems to the private sector as soon as possible. The Secretary also requested information in response to a set of eight specific items.

COMSAT has long been a proponent of commercializing the Government's civil weather and land remote sensing satellite systems. Nearly all of the issues and questions raised by the Secretary have been addressed in previous documents submitted by COMSAT to the Administration. COMSAT's EARTHSTAR concept was first presented in detail to the Secretary in the EARTHSTAR Document of December 14, 1981, and was updated on March 15, 1982. COMSAT also provided the Secretary with information related to the commercialization of the civil weather systems in its Response to NOAA Issue Paper (July 14, 1982) and information related to the need for an expedited and comprehensive administration policy in Need for a Prompt Policy Commitment (July 14, 1982). The latter two documents are included for ease of reference in Volume II of this response containing supplementary materials.

We have taken this opportunity to reexamine the EARTHSTAR concept in light of events since last year. We find that the opportunity for modification of the LANDSAT D Prime satellite to incorporate tape recorders and a high resolution solid state

2

stereo sensor, for all practical purposes, has disappeared because the satellite integration has been completed. As a result, the potential for significant development of commercial land satellite data sales has been pushed out to 1987. On the other hand, the French SPOT system is proceeding on schedule for a 1984 launch and will deploy a solid state, stereo capability. This puts the U.S. commercial operator in an increasingly greater competitive disadvantage the longer the transfer is delayed. Further procurement of replacement GOES satellites has proceeded pushing the opportunity to introduce less costly commercial replacements further out into the end of this decade. Therefore we find it necessary, in many respects, to amend and update our previous submissions and this response should be considered to supersede any prior inconsistent material.

LIKELIHOOD OF GOVERNMENT SAVINGS

We have examined the comparative costs of maintaining the present civil weather and land satellite systems in the Government with the cost of procuring data from a private source which would own and operate a central ground facility, and develop a new generation of weather, land and ocean sensing satellites to meet the data needs of the Government. We have attempted to estimate such costs on the basis of available information. Cost comparison material based on published information was submitted to the Government on December 14, 1981 and updated on March 15, 1982. Since then we have adjusted our prior analysis to reflect new information such as the material provided to industry on September 17, 1982, including the actual costs of GOES G and H satellites and reduced projections of the Government costs ascribed to the NASA Tracking and Data Acquisition Program through 1988 instead of 1985.

While it is difficult at this time to project the price of data to be provided to the Government by a commercial system pursuant to the arrangements discussed hereafter in Item 2, a comparison of Government costs, using the adjustments discussed above and application of valid functional cost comparison techniques, with projected commercial prices indicates that savings to the Government in the order of $1 billion (in constant 1982 dollars) are likely over the first ten years (FY84-93) of a commercial system. These savings would be generated, in part, by the payment of an estimated $250-350 million by COMSAT to the Government for the necessary Government assets. Additional savings could be provided by a negotiated arrangement for the Government to share in the successful development of the commercial markets. The annual charges to the Government for weather and land data and services would be determined by negotiation, but for the purpose of our savings estimates we have assumed a price of approximately $315-330 million a year. These estimates are made on the basis of certain assumptions, including the value and condition of the Government satellites and equipment, passage of necessary legislation in 1983, transfer effective January 1, 1984, and negotiation of a mutually acceptable long term contract.

COMMERCIALIZATION vs. RETENTION OF THE WEATHER SYSTEMS

The estimated savings shown above provide a sufficient basis to reexamine the current policy of retaining the civil weather satellites in the Government. The important issues relevant to the commercialization of the weather systems have been included in the set of detailed questions enumerated by the Secretary. These issues have been answered in detail in our Response to NOAA Issue Paper (June 14, 1982) and in the following discussion. In both our experience and our considered opinion, there are no issues that would bar the commercialization of the weather systems.

An examination of the weather satellite system indicates that commercialization would bring about much needed improvements. For example:

- o GOES procurement - A sole source procurement by the Government for GOES G and H satellites will cost approximately $140* million ($70 million apiece). Estimates from reliable spacecraft manufacturers indicate that equivalent or superior data could be obtained from satellites for approximately $90 million ($45 million apiece).

- o The VAS instrument - This instrument has been in experimental development for ten years. There are reliable sensors in use today which could be used on a 3-axis stablized satellite to replace the VAS and provide superior data at less cost.

- o DCS - The environmental Data Collection System (DCS) has been operational for over seven years, yet less than 50 percent of the potential capacity is being used. The use of the DCS system could be improved almost immediately by allowing decentralized communications, marketing excess capacity to commercial customers and improving the operating procedures.

In addition to these and other improvements a private entity could achieve, the commercialization of the weather satellites would be consistent with the economic policy of the President, the Governments commercialization policy enunciated in OMB Circular A-76 and the President's space policy.

ECONOMIC POLICY

The President stated, in the message to Congress submitting his Economic Report (February 1982), that "my first and foremost objective has been to improve the performance of the economy by reducing the role of the Federal Government in all its many dimensions."** The President described several common sense approaches to making Government more efficient and responsive, including:

- o "Federal Government action should be reserved for those needed functions that only the national Government can undertake."***

Retention of the weather satellite systems would not result in the reduction of the role of the Government. Further, operation of those systems to produce weather data is not an activity which only the national Government can undertake. As a general matter, the President's economic policy calls for private sector production of goods and services. Limited Government intervention is justified only in certain circumstances, such as to provide public goods. For example, the United States Government provides national defense but the private sector produces the articles and many services (e.g., planes, trucks, ships, communications, etc.) which are used to provide national defense. Given this division of responsibility in our economic system it is appropriate for the private sector to collect and produce satellite data for the Government and for the Government to use this data to provide the public with weather advisories and severe weather watches and warnings, i.e., needed public services. The transfer of the weather systems to the private sector would be in furtherance of the President's economic policy and consistent with the division of responsibilities between the private sector and the Government under our economic system.

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* Material supplied by NOAA at Industry Briefing (September 17, 1982).

** Economic Report of the President, 4 (February 1982).

*** Economic Report of the President, 5 (February 1982).

COMMERCIALIZATION POLICY

A policy of retention of the weather satellite systems is inconsistent with the commercialization policy of the Administration as reflected in OMB Circular A-76 (hereinafter A-76). The general policy -- which was reiterated by the Secretary in the preamble to the September 15, 1982 announcement -- is that the Government should not compete with its citizens since the private enterprise system is the primary source of our economic strength. Goods and services which are needed by the Government should be obtained from the private sector.

Under the criteria established by A-76 -- including cost comparison criteria -- the weather systems should be commercialized.

SPACE POLICY

On July 4, 1982, the President announced a national space policy that is to set the direction of U.S. efforts in space for the next decade. One of the basic goals of United States space policy is to:

> "-- expand United States private sector investment and involvement in civil space and space related activities;"

The principles underlying the conduct of the U.S. space program include:

> "-- The United States encourages domestic commercial exploitation of space capabilities, technology, and systems for national economic benefit. . ."

One of the policies which are to govern the conduct of the U.S. civil space program is that:

> "The United States Government will provide a climate conducive to expanded private sector investment and involvement in space activities. . .

We believe the retention of the civil weather satellite systems is antithetical to the above cited provisions of the space policy. On the other hand, commercialization of the weather systems, particularly in combination with the land system, would further the President's space policy by expanding private sector investment, and by commercially exploiting new space technologies and systems for national economic benefit.

BEST MECHANISM TO ACHIEVE SUCCESSFUL TRANSFER

The best mechanism to implement a transfer of the civil weather and land systems as soon as possible is to adopt a plan of commercialization to be submitted to Congress with implementing legislation. The plan should designate the entity to undertake the responsibility of developing a combined commercial remote sensing satellite system.

The selection of a private corporation to own and operate the systems should be based upon the interest expressed in response to the Secretary, as well as the technical and institutional qualifications, experience of the corporation, and preliminary negotiations carried to the point where the parties share confidence that a mutually satisfactory contract can be achieved. This is the only approach which could result in a transfer as early as January 1984. A transfer in January 1984 is necessary to provide the private corporation enough time to design and procure the next generation spacecraft necessary to maintain data continuity, consolidate the ground segments in a modern efficient facility and begin marketing of LANDSAT data in competition with SPOT when it is launched in 1984.

We believe that the responses to the request of the Secretary will provide adequate information for the Administration to choose the entity or entities with whom to negotiate. In order to effect a transfer in 1984, this decision should be made in November and the above-described preliminary negotiations concluded in time to reflect in the FY84 Budget the final decision on the entity and the arrangements along with estimated funding for implementation.

A milestone chart of these events would look like this:

Nov '82-Dec '82 -- Decision to transfer and combine weather and land systems, preliminary negotiations, selection of the entity to be designated to undertake commercialization, and preparation of budget materials.

Dec '82-Jan '83 -- Continue discussions regarding contractual and legislative features.

Feb '83-Mar '83 -- Budget released and legislation introduced.

Jun '83-Jul '83 -- Legislation enacted.

Aug '83-Oct '83 -- Final negotiations and execution of contract.

Jan '84 -- Commence implementation.

RESPONSES TO SPECIFIC ITEMS

The Commerce Business Daily announcement requested that the responses include specific information. Set forth below is the information requested.

1. A STATEMENT OF THE RECOMMENDATIONS AND RATIONALE FOR TRANSFER OF ALL OR ANY PART OF THESE (WEATHER AND LAND) SATELLITE SYSTEMS.

RECOMMENDATION

COMSAT recommends that the Government transfer to COMSAT, for a fair price, the GOES, NOAA (Tiros-N) and LANDSAT satellites and the NOAA, GOES and LANDSAT ground equipment and facilities located at Wallops Island, Virginia; Gilmore Creek, Alaska; and Suitland, Marlow Heights, and Greenbelt, Maryland. COMSAT would undertake the additional investment necessary to develop an integrated environmental satellite system which would include a centralized, modern satellite control and data processing center, and the next generation of satellites needed to maintain continuity of weather and land data to meet the needs of the Government. COMSAT is prepared to accept these responsibilities if (i) both weather and land systems are transferred; (ii) necessary legislation is passed in 1983 which designates COMSAT as the private entity responsible to develop the commercial system; and (iii) a long term contract is executed to supply data to the Government which assures the economic viability of the system in the early years.

RATIONALE

A discussion of the rationale for our recommendation is contained in the Response to NOAA Issue Paper (July 14, 1982) reprinted in Volume II.

2. A DISCUSSION OF THE TECHNICAL AND BUSINESS ASPECTS OF ANY PROPOSED TRANSFER, WITH PARTICULAR EMPHASIS ON CONTINUITY OF SERVICE AND COST SAVINGS TO THE GOVERNMENT.

TECHNICAL ASPECTS OF THE PROPOSED TRANSFER

Any commercial system must be able to assure that the transfer is accomplished without interrupting delivery of essential weather and land data. In addition, the transfer should take advantage of the current equipment in place or already procured by the Federal Government. A concerted effort to modernize and centralize ground systems also is critical to a more efficient and cost effective system. Satellite systems must also be continued beyond the current Government procurements. Decisions about future satellite designs and deployments should be made immediately after system transfer, even though current procurements extend service until the mid-to-late 1980's.

With these requirements in mind, we have developed a transition plan which is to be used if COMSAT is designated to develop a commercial system. It provides improved services and more modern and efficient ground facilities at a lower cost than the Government currently is incurring.

Ground System Plan

The ground system plan assures uninterruped continuity. It is based on the following tenets:

1. The existing weather ground systems are old and inefficient and need to be replaced.
2. The LANDSAT ground system is based on modern technology and equipment and should be retained as part of the proposed commercial system.
3. A modern centralized facility should be built to serve both the LANDSAT and weather systems. This facility should use hardware based on the LANDSAT ground systems design to enhance both systems reliability and flexibility through equipment standardization, networking and sharing.

Therefore, beginning at program go-ahead (assumed for illustrative purposes to be January 1984) the following existing Government facilities and equipments would be operated by the private entity:

- Building 28, Goddard Space Flight Center (GSFC), Greenbelt, Maryland
- Satellite Operations Control Center, Suitland, Maryland
- Central Data Distribution, Marlow Heights, Maryland
- Wallops Station, Virginia
- Gilmore Creek Station, Alaska

Beginning in 1986, all functions would be consolidated from the present five locations to a new central facility and Gilmore Creek in the following manner. The LANDSAT equipment in Building 28, GSFC, would be purchased and the building leased until a centralized facility in the Southwest United States is completed in early 1986. The Gilmore Creek Station and equipments would be leased on a long term basis. The weather systems control and processing equipment in Suitland and Marlow Heights, Maryland would be leased as well as the Wallops Station. During the period 1984 through 1986, the satellite systems would be controlled from these leased Government facilities.

In 1984 construction of a new central ground facility would begin, to be completed by 1986. The new central facility would have new antennas capable of communicating with all of the weather satellites, as well as the LANDSAT system. Domestic communication satellite transfer systems would also be included to relay raw data from Gilmore Creek, White Sands, and other collection points to the central facility and distribute data products from the facility to Government and commercial users. The new facility would be equipped with control, data acquisition, mission management and data processing equipment identical to that presently in place in Building 28 at GSFC.

Early in 1986, real time information from the LANDSAT satellite could be received and processed through the new central facility. The software would be transferred to the new central facility to support the pre-startup verification using real time data. As soon as verification is complete, control of the LANDSAT satellite and processing of LANDSAT data would be transferred to the new facility. Full uninterrupted operations would continue from the central facility and Building 28 operations would be shut down.

The LANDSAT equipment in Building 28 then would be transferred to the central facility. We believe this modern equipment can be used to process weather satellite data more reliably than with the current weather ground equipment and with the addition of some specialized equipment, be used for weather satellite control. This innovation would permit an uninterrupted and cost effective transition from the current Government facilities and equipment to a modern central commercial facility and equipment. As soon as the weather data can be processed with assurance, all weather satellite systems control and data processing would be transferred to the central facility. The equipment and facilities at Suitland and Marlow Heights, Maryland and Wallops Station could be returned to the Government.

Space Systems Plan

We would propose that the Government procurement of GOES end with GOES H so that an advanced commercial GOES system could be designed and procured. A new advanced GOES system would employ 3-axis stabilization, sensor redundancy and many of the lifetime extending design innovations used in commercial communications satellites. Block buy procurements and shorter procurement lead times would reduce costs. The resulting system should have a greatly reduced system cost by extending the satellite lifetimes from the currently projected four years to a seven year period.

Similarly, Government procurements should end with NOAA G. The design and procurement of the NOAA satellites beginning with NOAA H would include minimum block buys of four units and introduction of selected oceanographic sensors. We believe the following sensors could be included at little or no extra cost to the Government:

- o Radar scatterometer to measure winds, and
- o Coastal zone color scanner.

These sensors have proven designs and are available now. Other sensors, such as a wave spectral sensor or ice imaging sensor could also be added to the system at additional cost.

Improvements in the existing instruments used on the NOAA satellites would also be considered consistent with user requirements, cost and schedule. Lifetime extending redundancy and improved failure mode features can extend satellite lifetimes from the present two year life to a four year life.

The LANDSAT D Prime satellite would be launched in 1986. This launch would end the currently procured Government land satellites. Land remote sensing would continue with a modern system identified as LANDSTAR.

The LANDSTAR system would incorporate a three-channel, 10-meter IFOV, modern design linear array sensor that will provide stereo images with two base to height ratios, planimetric viewing and advanced data handling systems using already developed data compression systems pioneered by the COMSAT laboratories. A design for the LANDSTAR system already has been produced. Incorporation of additional sensing capabilities will be considered based on Government and user requirements and any necessary adjustment of the price to the Government.

The land remote sensing systems would be extended in future years under the name LANDSTAR, and future systems could include advanced linear array and synthetic aperture radar sensors, being considered by COMSAT at the present time via conceptual and feasibility studies, either individually or as multi-sensor payloads.

There are also many advantages in integrating weather and land remote sensing systems to:

- o Employ the wider field of view imagers on weather satellites to program, in real time, high resolution land sensors;
- o Employ the land remote sensing platforms to carry selected weather and ocean sensors.

Just as the ground system is centralized and integrated to reduce cost and to improve reliability, the flight systems will be considered as an integrated set, instead of separate and individual systems; to reduce cost and improve reliability.

BUSINESS ASPECTS OF THE PROPOSED TRANSFER

There are two principle business features of the proposed transfer -- the acquisition of the satellites and related facilities for a fair price and to enter into a long-term procurement contract with the Government for weather and land satellite data and services.

Our estimate of the value of the Government assets in 1984 is approximately $250-350 million. However, it should be realized that the price of the Government assets directly relates to the price of the data to be supplied to the Government; the higher the equipment cost, the higher the data price.

There are two major uncertainties associated with the development of a commercial system: (i) the cost of operating the existing Government systems until an efficient centralized facility and commercial space segment is in place; and (ii) the non-Government revenue potential of the system. We believe that the development of substantial non-Government markets for land satellite data will take a number of years and will not grow significantly until a commercial ground and space segment is in place late in the decade. Because of these uncertainties and the magnitude of the associated risk we believe that any agreement must incorporate the following principles.

- The term of the agreement covers at least the first generation of commercial satellites (approximately 15 years).
- The economic viability of the commercial system is assured in the early years by the Government especially prior to the operation of an advanced commercial land system.
- Gradual assumption by the commercial operator of the financial risk associated with the development of the commercial markets over the term of the agreement.
- Incentives to develop the non-Government markets and for the Government to share in the successful development of such markets.

We believe that these principles could be incorporated into a 15 year data contract which would include the following additional key provisions.

- Options for new data (new technology) with equitable price adjustments.
- Necessary obligational authority and appropriation for full contract amount.
- Payment upon data delivery or data availability.
- Best efforts basis by system owner/operator.
- Protection of proprietary rights in data.
- No Government competition for land data.
- Appropriate limitations on liability to Government and third parties.
- Management flexibility to modify and improve system efficiency and operation.

We have analyzed carefully the legal aspects of these terms and have found ample legal precedent for each. The key business terms of the proposed transfer are related to the financing of the proposed system. In our opinion, the business must be capable of being project financed. The required investment and accompanying risk involved in developing a commercial remote sensing satellite system is so large that such an undertaking must be self supporting and the financing obtainable on a non-recourse, project financing basis.

The key to project financing is a data contract that will cover, at least, the first generation of spacecraft that must be procured to maintain continuity of service and that will provide an adequate opportunity to develop commercial markets for remotely sensed satellite data users. We believe that a 15 year contract is required -- and reasonable -- since the procurement of the first generation of commercial satellites must begin in 1984 to provide continuity of data and block buys of four or more satellites (providing the space segment for a 15 year period) would be required to achieve meaningful cost reductions.

COST SAVINGS

Cost savings of at least $1 billion over a ten year period (FY84-93) are estimated as have been described more fully above on page 2.

3. A DESCRIPTION OF THE TERMS AND CONDITIONS THAT ARE NECESSARY FOR A SUCCESSFUL TRANSFER. THIS SHOULD INCLUDE, BUT NOT NECESSARILY BE LIMITED TO:

   a. Any desirable or undesirable Government regulations.
   b. Any need for legislation.
   c. Use of Government facilities, ground stations, and equipment.
   d. Services to be provided to the Government and the public.
   e. Time frame in which transfer is considered feasible.

GOVERNMENT REGULATION

We believe that regulation should be kept to a minimum; the benefits regulation would otherwise seek to provide can be accomplished through the data contract. Regulation not only adds to the taxpayer burden of maintaining any Government regulatory mechanism, but adds to the costs of the producer which result in increased costs to the consumer. There is no need to regulate data prices charged to the Government. In the negotiation of the data contract, the Government would have access to the costs, projected profits and other financial data of the selected company. There would be equal bargaining power and full disclosure of the relevant facts. The contract and price negotiations are an appropriate substitute in these circumstances for economic regulation.

Nevertheless, NOAA has questioned what mechanisms are available to prevent a sole source supplier of weather data from arbitrarily increasing prices. In fact, the Government relies, in many situations, upon a single source to provide products for essential national programs. A fixed price over a set term protects the Government from arbitrary price increases. Further, the selection of a contractor who is experienced and reliable would provide the Government reasonable assurance that the product or service can be delivered at the agreed price. We believe that both of these requirements can be achieved and no further protection for the Government is required.

We also believe there is no need to regulate the pricing of weather data sold to non-Government customers. Weather data will be supplied to the National Weather Service to be used for preparation of weather forecasts, advisories, warnings, and watches and be distributed to the public. Distribution of this data by the Government will therefore effectively control the prices which can be charged by the entity for the same data marketed to commercial customers who desire to obtain data more quickly than data can be obtained from the Government or who require data in a more useful format.

The situation with regard to land satellite data is similar to weather data inasmuch as the Government is a primary customer and a data contract negotiation provides the necessary control. Likewise, there is no need to control the prices for data sold to non-Government users because competition in the marketplace will regulate pricing. Competition will exist from the French SPOT system, the planned Japanese and ESA systems, and from aerial photography. Other restraints on pricing include the need to develop a market for data which has been available from the Government for the price of reproduction, and the potential competition for the Government data contract after the initial term. All of these factors taken together make plain that there is no need for Government price or rate regulation.

On the other hand, there may be other matters of public interest which will not properly be provided for in the marketplace. Such matters as national security and foreign relations can be adequately provided for in a contract as explained in Response to NOAA Issue Paper (June 14, 1982) in Volume II.

LEGISLATION

We have given considerable thought to the necessary elements of enabling legislation to implement a commercialization of the weather and land sensing satellite systems. Based on our examination to date, we would consider the following provisions to be key to remote sensing satellite legislation.

The legislation should provide for the establishment as expeditiously as possible of an integrated weather and land commercial remote sensing satellite system by transferring the Government's civil weather and land remote sensing satellite systems to a designated private entity under appropriate terms and conditions, and by assigning to it the responsibility for the establishment, ownership and operation of such a system and the development of a commercial market.

The legislation should provide that nondiscriminatory access to data must be accorded to non-U.S. Government users, both domestic and foreign, pursuant to commercial terms and conditions.

The President's responsibility to carry out the provisions of the Outer Space Treaty should be effected by empowering the President to authorize the establishment and operation of any remote sensing satellite for which the United States is the seat of registry under the provisions of the Convention on the Registration of Objects Launched into Outer Space, or which is owned by a person subject to the jurisdiction of the United States.

The legislation should require the President to oversee the operation of any remote sensing satellite to ensure that remote sensing technology is used in a manner which is not inconsistent with the national security, foreign policy, treaty obligations and laws of the United States.

The President should exercise supervision over the relationships of the corporation with foreign governments, entities and international bodies.

The legislation should set the basic terms of the contract for the transfer of the satellites and related assets and the procurement of satellite data and services. Such terms should include:

- Procurement by the Government of all its requirements for data and services for a minimum period of fifteen years and provision for contracting for additional or new data or extending the term of the contract.

- The procedure by which the President may issue directions regarding the acquisition or dissemination of data for reasons of foreign policy, national disaster, national emergency or national security.
- Payment of any liability of the Government which may accrue (including termination by the Government for its convenience).

The legislation should provide that data and data products be fully protected against unauthorized use or misappropriation. It should be made clear that data and data products are the proper subjects of copyright and that copyright protection shall be available for data and data products. Consideration should also be given as to whether exemption from the provisons of the Freedom of Information Act (FOIA) needs to be be included. We would suggest that the Administration solicit an opinion of the Attorney General on this subject to ensure that such data would not be available through FOIA. If the Attorney General cannot give a satisfactory opinion, then legislation should provide a specific exemption from FOIA.

USE OF GOVERNMENT FACILITIES

As discussed in more detail in Item 2 above, we propose to purchase or lease the Government facilities located at Wallops Island, Virginia; Gilmore Creek, Alaska; and Greenbelt, Suitland and Marlow Heights, Maryland.

In addition, the use of the Government's TDRSS communications services for the acquisition of LANDSAT data would be required. The use of Government launch services and arrangements made for the GOES, NOAA and LANDSAT satellites also would be required.

SERVICES TO BE PROVIDED TO THE GOVERNMENT AND THE PUBLIC

A description of the services to be provided to the Government and the public is set forth in the Response to NOAA Issue Paper (July 14, 1982) reprinted in Volume II and in Item 4 below.

TIME FRAME IN WHICH TRANSFER IS CONSIDERED FEASIBLE

From a technical standpoint a transfer could begin within a few months of the execution of a contract. Considering the political process, we believe that a transfer is feasible as early as January 1984 if the Government proceeds on a basis such as we have outlined herein. However, if the Government proceeds on a basis other than the selection of a designated entity for combined commercial weather and land satellite system, it is highly likely that a transfer would be delayed until 1986 or later. Such a delay, as we have pointed out in our discussion herein and in the Need for Prompt Policy Commitment (July 14, 1982) contained in Volume II, would make it more difficult to compete with the French SPOT system, make the cost of commercialization higher, and make it more difficult to transfer the systems out of the Government.

4. A DESCRIPTION OF THE PROPOSED REMOTE SENSING SYSTEM AND ITS CAPABILITIES.

We have given considerable thought to the area of coverage, spatial resolution, sensor frequency bands, interval between repeat coverages of a ground site and other pertinent system parameters of a system we would develop if assigned the responsibility by legislation in 1983. We have also considered the necessary plans for direct transmission of data to foreign ground stations and distribution of data to international and domestic customers.

SHORT TERM

As indicated in Item 2 above, a transfer of the present Government systems would result in the short term with a space segment very similar to the system that now exists. Existing GOES and NOAA procurements create a situation where both of these satellite systems will continue as they are until the period 1988-89. A new ground system could be in place in 1986, but it would be communicating with existing satellite designs for the first three years of its operation. A similar situation exists with LANDSAT where the LANDSAT satellites could extend to the '88-89 period. Although a new commercial ground system would improve input data formatting, data processing and product services equipment, it would be operating on the existing data sets. Therefore, coverage, spatial resolution bands and the interval between repeat coverage would continue as they are at the moment. LANDSAT data would be made available to all customers on a nondiscriminatory commercial basis, and even though direct reception of data using the TDRSS satellite system would improve coverage, foreign ground stations would still be collecting and processing data under commercial agreements which would replace the existing Government agreements. Although we expect that the fee structure will change in line with economic changes, the basic agreements should be structured to operate substantially as they do now.

Weather data would be distributed via the Government network and international agreements to support the WMO arrangements.

ENHANCEMENT OF EXISTING SYSTEMS

Due to the constraints of time and the practicalities of making extensive changes to existing and under contract satellite systems, it may be impossible to make changes to the current GOES F-H, the NOAA D-G, and the LANDSAT D Prime satellites.

EVOLUTION OF A COMMERCIAL SYSTEM

Beginning in 1988-89, three types of new satellites could be launched. A new GOES system could be based on a design that would concentrate on extending the GOES lifetime and produce reductions in life cycle cost. To accomplish this objective, the final design and procurement of these new systems would begin in 1986. The new design would include redundant sensors and support systems. We believe that a 3-axis stabilized satellite platform using staring sensors will produce data nearly identical to the data produced by current systems; resolution and spectral performance would be similar to the existing systems. COMSAT has some unique proprietary ideas about equipping these geostationary platforms also to serve a commercial system as communications nodes.

The new NOAA (Tiros-N) satellites could also be introduced with NOAA H in the late '80's. We believe that oceanographic wind and wave monitoring sensors, ocean color imagers, and ice mapping sensors are all candidates for the future NOAA polar orbiting environmental monitoring systems. We feel that a gradual and phased introduction of these systems is important unless customer response warrants dedicated platforms to make these measurements. Our foreign neighbors are already making plans and establishing designs and manufacturing schedules to provide these capabilities to their own users in the late '80's time frame. We believe the United States, which developed these systems, must introduce these capabilities in that time frame to remain commercially competitive in the world market.

A LANDSTAR system also would be introduced to follow LANDSAT D Prime. We have developed a design for LANDSTAR A that would include a three telescope sensor using linear array detectors, a data compression system, on-board tape recorders and a transmission system capable of providing global coverage. Each telescope would have a 15 degree view angle producing a swath width on the earth's surface of 185km. The stereo sensor would have a spatial instantaneous field of view of 10 to 15m and would provide three channels in the wavelength region for .6 to 1.2 microns. The telescopes will be arranged so that one will have a forward view of 24 degrees, one an aft view of 24 degrees, and one will be pointed straight down at the nadir. Combination of views of the same scene will produce stereo base-to-height ratios of .49 to 1. All three telescopes will operate simultaneously. A detailed description of the stereo sensor and operation, including ground data collection, is available to the Government.

LANDSTAR B and C would evolve the high resolution, multispectral land remote sensing theme by considering the following options:

- Improved resolution and spectral content.
- Introduction of high resolution radar imagers
- Synthetic Aperture Radar.
- Combinations of linear array and radar imagers on the same platform producing unique stereo.

Special attention also would be placed on improving the ground registration capabilities of the sensor, satellite and data processing systems.

5. ANTICIPATED EVOLUTION OF NEW OR IMPROVED SENSING CAPABILITIES UNDER THE PROPOSED TRANSFER, AND RECOMMENDATION FOR A MEANS TO ASSURE THAT EVOLUTION.

ANTICIPATED NEW OR IMPROVED CAPABILITIES

As indicated in Items 2 and 4 above, a commercial system could introduce new sensors, data compression, communications and data storage improvements. These will be discussed in order.

Sensors

A discussion of new sensors can be found under Items 2 and 4, above.

Data Compression

COMSAT has been working for several years on data compression techniques suitable for use in space. These techniques will permit from three to ten times reductions in data rate for all data including high resolution imagery. The need for satellite data storage and transmission economies are obvious in light of the rapidly increasing data rates associated with modern high resolution imaging sensors. Data compression is one of the significant ways that satellite and ground system costs could be reduced since data rate is a costly element of systems design.

Communications

One of the innovations that could be used is the direct and inexpensive broadcast of data products to users, using communications elements such as the direct broadcast TV approach. A centralized ground system should be located in the Southwest United States because of the high altitude and low rainfall advantages for communications of X and K band frequency transmissions. Our experience with some of our other communications facilities indicate that this is a wise choice for reasons having to do with construction costs.

Data Storage

The use of compression techniques on board the spacecraft would permit the use of more reliable lower rate tape recorders and would allow the storage of large volumes of data for playback. Large volumes allow greatly improved geographic coverage per unit of storage. On the ground, the central facility could be equipped with optical disk recorders. The use of this technology could reduce the per bit cost of information storage by a factor of 10,000 and will extend storage lifetime considerably. Large data archives would no longer pose the maintenance and space problems that they now create. Access times would also be improved as the optical disk systems could be used to store data in digital form and products, both CCT and film, could be created quickly using modern transcription devices such as OPTRONICS and MDA film writers.

Sensor Combinations

The total integration of space systems as well as ground systems should be explored. These possibilities have been discussed in Items 2 and 4 above.

Assurance of Evolution

The development of a combined environmental (land, weather, and ocean) sensing system should be on a business basis. Marketing research should be closely tied to both sensor and systems development activities that will pace new satellite and ground systems designs. As we expect the Government to continue to be a major customer for environmental data, the requirements of the Government will drive advanced system design and will guarantee systems evolution to meet expected Government needs. The marketplace, outside of Government interests, will also influence future systems development.

6. RESPONSE TO FOREIGN COMPETITION AND ITS EFFECTS.

See Need for Prompt Policy Commitment (July 14, 1982) and Response to NOAA Issue Paper (July 14, 1982) reprinted in Volume II for a full discussion of this subject.

7. POTENTIAL FOR COMMERCIAL INTERNATIONAL JOINT VENTURES IN REMOTE SENSING AND THEIR IMPLEMENTATION IN THE AREAS OF EXPORT CONTROLS AND NATIONAL SECURITY.

We foresee both advantages and disadvantages to international remote sensing joint ventures. We believe that any type of international commercial venture requires the participation of a strong private sector entity on behalf of the United States. Therefore, the U.S. should move quickly to designate a commercial operator. In the short term there may be some potential for bilateral ventures or perhaps ventures with three or four participants in land sensing systems. Eventually there may be a need and potential benefit of forming a multilateral venture involving both developed and developing nations. However, we see no immediate economic or business need for a multilateral venture if the United States combines its weather and land systems under a private operator.

There are existing export and national security controls which would apply to an international venture. We are familiar with the application of these controls with regard to INTELSAT and INMARSAT. We do not believe they would cause insurmountable difficulties if an international venture would otherwise substantially benefit the United States.

8. IF TRANSFER IS RECOMMENDED FOR ALL OR PART OF THE CIVIL WEATHER SATELLITES SYSTEMS, INFORMATION SHOULD BE SUPPLIED ON:

   a. Assumption of command and control by the Department of Defense in emergencies.
   b. Effect of providing selected priority service to defense needs when required.
   c. Feasibility and savings associated with combining weather and land satellite functions (space and/or ground segments), and recommendation.
   d. Use of existing Government facilities, ground stations, and equipment inventory.
   e. Use of existing industry facilities, ground stations, and equipment inventory.
   f. Proposed criteria for launching replacement satellites and selection of orbital parameters.
   g. Weather satellite service costs under the proposed transfer to permit comparisons with current costs.
   h. A statement of the pricing and data distribution practice (domestically and internationally) that would be employed for weather data.
   i. Intended approach to the evolution of sensor systems still in the research and development stage, such as the VAS on the geostationary weather satellites.
   j. Approach to be used with foreign supplied instruments, such as ARGOS and SSU on the polar orbiting weather satellites.
   k. Approach to respond to the National Weather Service priorities for severe storm data (National Severe Storms Forecast Center in Kansas City and National Hurricane Center in Miami) and for major forecast operations (National Meteorological Center in Camp Springs, Maryland).

ASSUMPTION OF COMMAND AND CONTROL

This matter is thoroughly discussed in Response to NOAA Issue Paper (July 14, 1982) reprinted in Volume II.

PRIORITY SERVICE

This matter has been thoroughly discussed in Response to NOAA Issue Paper (July 14, 1982) reprinted in Volume II.

FEASIBILITY AND SAVINGS

These subjects have been discussed under LIKELIHOOD OF GOVERNMENT SAVINGS on page 2 and in Items 1, 2 and 4 above.

USE OF EXISTING GOVERNMENT FACILITIES

See discussion under Item 2 above.

USE OF EXISTING INDUSTRY FACILITIES

See discussion under Item 2 above.

REPLACEMENT SATELLITES AND ORBITAL PARAMETERS

The Government should establish the replacement criteria for the weather satellites as part of the statement of requirements. A commercial operator would respond by designing, procuring and operating satellites to meet those requirements.

WEATHER SATELLITE SERVICE COSTS

Our estimates indicate that over a ten year period the cost of the assets devoted to weather services are about 70 percent of the total cost of assets for a combined weather and land system. The annual charges to the Government for weather and land data and services would be determined in the negotiations, but for purposes of our savings estimates we have assumed a price of approximately $315-330 million; approximately $220-230 million would be for weather data and services and approximately $95-100 million would be for land data.

PRICING AND DATA DISTRIBUTION PRACTICE

See discussion under Item 3 above and Response to NOAA Issue Paper (July 14, 1982) in Volume II.

EVOLUTION OF SENSOR SYSTEMS

See discussion under Item 4 above.

FOREIGN SUPPLIED INSTRUMENTS

The National Earth Satellite Service (NESS) presently has an agreement with the French National Space Center (CNES) pursuant to which CNES provides the satellite data collection system carried on the NOAA (Tiros-N) satellites. The United Kingdom Ministry of Defense (MOD) provides a stratospheric sounding unit (SSU) also which is carried on the NOAA (Tiros-N) satellites. We understand that the agreement with CNES will be renewed and that a new agreement involving a new instrument is being negotiated with MOD.

The renewal of the Agreement with CNES and the negotiation of a new agreement with MOD must take into account whether and when these systems are to be transferred. However, the transfer of the weather satellites to the private sector would not disrupt the existing agreement. All the existing agreements should be fully honored. We believe continuation of the Agreement with CNES and negotiation of a new agreement with MOD could be accomplished which would take into account the interests of all parties.

NATIONAL WEATHER SERVICE PRIORITIES

Priority service to the National Weather Service is essential for a commercial system. Within the parameters of the system, the Government should establish the priorities for acquisition, processing and delivery of weather data. All commercial services would be subject to preemption and/or interruption if necessary to meet the priority needs of the Government.

In order to respond to the needs of the National Weather Service, direct and reliable communication links would be established with Kansas City, Miami and Marlow Heights (Camp Springs) for both delivery of data and communication if COMSAT were designated to develop a commercial system. Arrangements also would be established for the receipt and response to the priority needs of the NWS according to the standards established by the Government.

EarthStar

COMMERCIALIZATION of CIVIL REMOTE SENSING

VOLUME II
SUPPLEMENTARY MATERIALS

COMMUNICATIONS SATELLITE CORPORATION
COMSAT

COMMERCIALIZATION OF CIVIL REMOTE SENSING

NEED FOR PROMPT POLICY COMMITMENT

Factors requiring a prompt decision by the Administration to transfer the Government Civil Weather and Land Satellites to the Private Sector.

Communications Satellite Corporation
and
COMSAT General Corporation

(July 14, 1982)

NEED FOR A PROMPT POLICY COMMITMENT

There is an urgent need for an unequivocal Government policy commitment in support of the commercialization of civil remote sensing. COMSAT wishes to renew its commitment to work in concert with the Government to avoid a loss of U.S. leadership in this vital area. Every day of delay makes less likely the possibility of incorporating technologies into Landsat D Prime which will enable the data from that satellite to compete commercially with data expected to be available from French and Japanese remote sensing systems scheduled for launch in late 1984 and 1988 respectively. Failure to include market responsive technology on Landsat D Prime will give our foreign competitors a lead that may well prove to be insurmountable for the remainder of this decade.

In these circumstances, there is growing concern that U.S. leadership in civil remote sensing is seriously threatened by the lack of a clear Federal policy commitment to meet the increasing challenges from national systems of other countries. COMSAT shares that concern. Failure to make the policy decision to commercialize now -- that is, so that it can be carried forth in the FY84 budget now under development -- will itself constitute a decision, albeit by default, not to commercialize in the foreseeable future. The United States would in essence be abandoning its substantial national investment in the development of remote sensing to exploitation by other nations -- particularly to France and Japan -- which will soon have their own operational remote sensing systems.

During the past 15 months COMSAT has presented a proposal to purchase and operate under a long term contract the Government's civil weather and land remote sensing satellites and the associated earth stations as part of an integrated earth environmental satellite system which we call "EARTHSTAR." Our proposal is intended to be responsive to the Government's expressed desire to reduce expenditures for civil remote sensing data and provides an economical solution to what has in a sense become a "chicken and egg" dilemma facing the Government in attempting to transfer only the land remote sensing satellites to the private sector. On the one hand, the Government recognizes that the commercialization of land remote sensing can be accomplished far more effectively by the private sector with its profit incentive and superior marketing abilities. However, on the other hand, the private investment required to acquire the system of land sensing satellites and earth stations and the time and money needed to establish a mature non-Government market for such data makes the commercialization prospects of land sensing unattractive to private enterprise absent substantial Government subsidies.

EARTHSTAR resolves this dilemma in that the projected revenues from the weather operations combined with economies made possible by integration and efficient operation of weather and land systems together constitute an attractive business proposition while at the same time providing more weather and land data to the Government at less cost. The establishment of the EARTHSTAR system would provide needed assurances of data continuity to encourage investment by users and the value-added industry and, thereby, develop commerical markets and uses for the data. COMSAT would operate the satellites to collect weather, land and, eventually, ocean data which it would furnish in raw and preprocessed digital and photographic form on a timely basis to meet the varying requirements levied by the Government and other users, both domestic and foreign, for such data.

COMSAT's EARTHSTAR system would also serve as a logical first step to any eventual United States participation in an international land remote sensing system should the governments concerned choose to move in that direction. From our past comparative experiences with the establishment of INTELSAT and then INMARSAT, the importance of the Federal Government choosing the private U.S. participant in such an organization before commencing negotiations for the formation of the organization cannot be overemphasized. The U.S. investor's participation from the outset is crucial, expecially in formulating such commercial aspects of the organizational arrangements as financing, marketing, procurement and data rights.

Not only does EARTHSTAR represent an attractive business opportunity to COMSAT, but we also estimate that there would be significant cost savings to the Government. These savings could amount to as much as $600 million in the first five years of operation and $80 million each year thereafter under the assumptions contained in COMSAT's proposal. These include an assumption that the Government would continue its program of basic research and development in remote sensing technology and that COMSAT would perform significant applications research and development.

These important advantages of EARTHSTAR would contribute significantly to ensuring continued United States prominence and leadership in the field of civil remote sensing and, thereby, avoid an otherwise probable situation in which U.S. civil remote sensing users, both Government and private, become increasingly dependent upon foreign collection systems for data. We believe EARTHSTAR is the most efficient and economical way for the United States to assure continuity and to maintain and strengthen its leadership in civil remote sensing.

The alternatives to EARTHSTAR are politically and economically less attractive: namely to make massive new program expenditures for continuation and expansion of the present Government-owned and operated systems; to grant substantial Government subsidies, both in money and equipment, to support a transfer of only the land remote sensing satellites to the private sector; to proceed promptly with the internationalization of land remote sensing; or to do nothing. The latter -- which appears to be the course the Administration is presently following -- foretells a reduction in the weather sensing capability, the elimination of the land sensing capability after LANDSAT D Prime and a non-existent ocean sensing capability. Such a course would -- if continued -- most certainly lead to an early demise of U.S. leadership in an increasingly important area of space applications, which President Reagan in his recent remarks at Edwards Air Force Base estimated "has saved hundreds of millions of dollars per year in agriculture, shipping and fishing." To do nothing also would be inconsistent with the renewed emphasis placed by the President on the importance of the civil space program as evidenced by this recent Directive on Space Policy and his establishment of a Senior Interagency Group on Space.

If the United States is serious about the commercialization of remote sensing, it must now make the policy decisions necessary to the prompt implementation of such a program. Further delay by the Government while foreign national programs proceed to fruition will make it extremely difficult, if not impossible, for any private company to overcome the foreign momentum without substantial Federal subsidies on a scale not heretofore contemplated and certainly unrealistic in view of budget and political restraints for the current and foreseeable periods. Substantial subsidies are not a satisfactory long- term solution from a Government or commercial standpoint. This is especially true where a main objective of transition to the private sector should be to put the system on an economically viable footing at the earliest practicable date.

The reasons supporting a transfer of both the land and weather satellites are evident -- economic viability, cost benefits, continuity, international leadership -- and there are no issues that otherwise bar commercialization. In testimony at Congressional hearings on remote sensing in July, 1981, we emphasized that the United States was at an important crossroads with regard to civilian remote sensing and suggested prompt action lest we be overtaken by the emerging remote sensing systems of the French and Japanese. A year later we remain at the crossroads. Only the competitive environment "landscape" has changed: The French and Japanese programs are a year closer to fruition. What progress has the United States made in the interim?

COMSAT is prepared to proceed with the Government under mutually satisfactory arrangements to ensure that the United States retains a prominent role in the future "landscape" of civil remote sensing.

COMMERCIALIZATION OF CIVIL REMOTE SENSING

RESPONSE TO NOAA
ISSUE PAPER

Issues to be considered in determining whether the civil weather remote sensing satellites should be transferred to the private sector or retained in the Government.

Communications Satellite Corporation
and
COMSAT General Corporation

(July 14, 1982)

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EXECUTIVE SUMMARY

The declining Federal resources for remote sensing and the foreign threats to U.S. commercial and technical leadership call for transfer of the U.S. Government programs to the private sector for development of the commercial potential. COMSAT proposes a means of developing the commercial potential in a manner that has a good business foundation and that will benefit the country -- transfer of the weather and land system to the private sector for integration into a commercial system.

NOAA has set forth the issues related to the commercialization of the civil weather satellites under four general topics. In both our experience and our considered opinion, each of the issues specified by NOAA can be managed satisfactorily in the context of contractual arrangements between the Government and COMSAT without the need for a complex regulatory mechanism. In our judgement, there are no issues which should bar the commercialization of the weather satellites.

- Command and control required for national security can be satisfied by formal and informal arrangements between the Government and COMSAT. Priority service to DOD, denial of satellite and data control to hostile powers, transfer of operations in national emergencies and support to classified programs can be provided without conflict with commercial objectives.

- All necessary flexibility and responsiveness can be achieved to ensure that the needs of the Government for data and services will be satisfied without conflict with a commercial operation.

- Long range research and development of new sensors and technology can be enhanced by commercializing the weather satellites.

- Necessary regulation of a commercial weather satellite system could be accomplished through contractual means without the creation of a complex, formal regulatory regime. The Government's economic, data, national security, and international requirements and interests can be protected adequately by contract.

From a broader perspective, the benefits of commercialization far outweigh the nominal administrative costs of transferring these activities to the private sector. For example, substantial reductions in Government outlays could be achieved -- by as much as $600 million over the first five years and by as much as $80 million each year thereafter -- if weather and land systems are both commercialized. Commercialization of the civil weather satellites is consistent with the President's Economic Recovery Program and is consistent with, if not required by, the existing Government and Administration's general policy of commercialization.

I. INTRODUCTION

Set forth below are the responses of COMSAT to the issues raised by the National Oceanic and Atmospheric Administration (NOAA) as issues which need to be considered in determining whether the civil weather satellites should be transferred to the private sector or retained in the Government. As we understand it, these are the only remaining issues to be considered in determining whether to adopt a policy of private ownership and operation.

These issues are not new to COMSAT. Indeed, many have previously been dealt with successfully in the context of satellite communications service arrangements between COMSAT and the Government in which satellites were used for both commercial and governmental purposes, such as the current MARISAT UHF service to the United States Navy and the earlier NASCOM communications services furnished to NASA for its Apollo program.

The NOAA Issue Paper requests that we address the issues in "an overall system and management context, and not by only an enumeration of technical considerations and their proposed solution." Therefore, in Part II of this response we summarize the overall context of satellite remote sensing in the United States and the proposed EARTHSTAR system, service, management, institutional and contractual arrangements as a background for our response to the detailed issues.

The four general topics set forth in the NOAA paper are: (1) command and control; (2) flexibility and responsiveness, (3) long range research, and (4) regulation. These topics will be addressed in Parts III, IV, V, and VI, respectively.

We have also included in Part VII a discussion of the net effects of commercializing the civil weather satellites in terms of system and management effectiveness, efficiency, costs and other factors.

II. EARTHSTAR SYSTEM AND MANAGEMENT CONTEXT

> "It is evident that the factors stated above must be addressed in an overall system and management context, and not only by an enumeration of technical considerations and their proposed solution." (NOAA Issue Paper)

A. EARTHSTAR CONCEPT

The United States has made a substantial investment in the initial development of satellite remote sensing technology and there is a very significant commercial potential, both domestic and foreign, for remotely sensed satellite land, ocean and weather data. However, the Administration has decided that the Government can no longer afford to carry the total costs of these satellite systems much less the cost of developing the commercial potential. The result is that the Administration has proposed that the U.S. weather sensing capability be reduced, and the land sensing capability be eliminated after LANDSAT D Prime. An ocean sensing capability is non-existent. At the same time the Europeans and the Japanese are aggressively moving to exploit commercially in new land and ocean sensing programs the technology initially developed in the United States.

The combination of diminishing Federal resources for remote sensing and foreign threats to U.S. commercial and technical leadership underscore the importance of developing the commercial potential of remote sensing by transferring the Government civil programs to the private sector.

The Government has been considering the transfer of the civil land remote sensing program -- LANDSAT -- for a number of years. However, the establishment of a privately owned and operated land system faces a dilemma. On the one hand, the development of the markets necessary to support a commercial remote sensing business will not take place until the Government's LANDSAT system is transferred from the Government to the private sector because of the absence in the Government of incentives to aggressively market data, service customers and develop new products. On the other hand, the investment required by the private sector to take over the existing Government LANDSAT system and develop an efficient commercial replacement land satellite system, combined with the period required to develop a mature market for land data, makes a commercial venture unattractive.

COMSAT's solution to this dilemma is the EARTHSTAR concept of transferring both the separate Government civil weather and land remote sensing satellite systems to private ownership and operation and integrating them into one efficient commercial system. This solves the dilemma posed by commercialization of the land system alone in that the economies and efficiencies of private operation of a combined system, together with a developed Government market for weather data, reduce the investments to a level and risk that is acceptable to a commercial venture. It also meets the Government's need to reduce expenditures. Possible savings of $600 million are estimated over the first five years and $80 million each year thereafter.

Integration of the weather and land systems is central to the EARTHSTAR concept. Without the weather satellites, commercialization of LANDSAT would not be attractive unless the investment, risk and payback period by the U.S. commercial participant could be reduced by other means such as a continued high Government payment for land data or internationalization of land remote sensing.

The concept of an integrated weather, ocean and land system is not a new concept. A Government report to the Administrator of NASA by an Interagency Task Force on Integrated Remote Sensing Systems (July 15, 1979) concluded that integration of weather and ocean space segments or the weather, ocean and land ground segment data reception and preprocessing systems, or both, appears to be technically attractive and cost effective. While the study examined the possibility of integrating the civil and military polar orbiting satellites as well as civil ocean and land satellites, we are not proposing that the civil and military weather systems be integrated. We stand prepared to provide the Department of Defense (DOD) data and services as required. However, our proposal is limited to the transfer of the Government civil weather and land remote sensing systems and the development of a civil ocean sensing capability.

B. THE EARTHSTAR PROPOSAL

COMSAT is prepared to acquire the Government's GOES (geostationary weather), NOAA (polar orbiting weather), and LANDSAT (polar orbiting land) satellites and related equipment and facilities for an estimated $300 million and to invest an estimated additional $2 billion in new satellites and facilities over a ten-year period to develop a commercial civil remote sensing satellite system called EARTHSTAR. COMSAT would acquire these satellites and make the necessary additional investment on the basis of a long term Government commitment to procure satellite data and services from COMSAT and the expected development of the commercial market. Our projections indicate that we could supply the Government with more data at less cost than if the Government continued to operate these programs.*

C. EARTHSTAR SERVICES

1. Weather data

COMSAT would provide the National Weather Service, DOD and other specified Government agencies raw and preprocessed weather data in digital and photographic form. Data which would be made available would be obtained from the GOES geosynchronous satellites located over the Atlantic and Pacific Oceans, and from the NOAA polar orbiting satellites (which provide morning and evening weather coverage). As is presently the case, the National Weather Service would continue to disseminate the weather satellite data and enhancements to the public and to foreign weather organizations through the existing weather data dissemination networks. In addition, consistent with national security requirements, COMSAT would make the weather data available to other users and value-adding companies which desire to acquire data directly from COMSAT under commercial terms and conditions.

COMSAT would continue to provide the existing direct weather data readout (e.g., Automatic Picture Transmission, High Resolution Picture relay, Direct Sounder Broadcast), satellite weather data distribution, (e.g., Wefax), and environmental data relay services to the Government and other users. Environmental data relay services would be made available to non-Government users on a commercial basis.

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* The assumptions and conditions under which we would implement the EARTHSTAR system are set forth more completely in the EARTHSTAR Document of December 14, 1981 (EARTHSTAR Document) and the EARTHSTAR Update of March 15, 1982 (EARTHSTAR Update).

2. Land data

COMSAT would provide designated Government agencies raw and preprocessed land data in digital and photographic form. The data which would be made available would be obtained from the sun-synchronous LANDSAT satellites, a high resolution land stereoscopic satellite launched in 1986 and new land sensing satellite devices brought into service in 1988-89, e.g., satellites with sensors such as a solid state multi-spectral linear array imager, a synthetic aperture radar imager, and various all-weather ocean and ice monitoring sensors.

COMSAT would provide land data to the Government for its internal use. These data also would be made available by COMSAT on a nondiscriminatory basis, under commercial terms and conditions, to non-Government users and value-adding companies. Foreign direct readout of land satellite data would be continued under commercial arrangements that would be negotiated with appropriate oversight by the Government.

D. DEVELOPMENT OF AN INTEGRATED COMMERCIAL SYSTEM

The development of an integrated commercial system will require the coordination and implementation of several activities, including: (1) smooth transfer of the existing systems from Government to the private sector; (2) integration of the space and ground segments; (3) initiation of commercial R&D; and (4) commercial market development.

1. Transfer of the existing systems

A major priority in the initial years will be the smooth transition of these system assets and operations from the Government to COMSAT. The principal objective of the transition is, of course, the assured continuity of data flowing from the environmental satellites to support existing Government and other user requirements.

The transfer of the control of the GOES, NOAA and LANDSAT satellites could begin almost immediately after completion of the necessary contractual arrangements.

2. Integration of the satellite systems

Another priority would be the integration of the ground control and data processing functions. By 1986, a centralized system could be in place which would consolidate the command, control, data acquisition, and processing functions in one location to achieve cost efficiencies and quality control. All administrative, management, engineering and research functions would be unified. COMSAT also intends to combine weather, land, and sea remote sensors and data relay capabilities which are feasible and desirable for the EARTHSTAR system. Future significant cost savings are certainly possible through satellite sensor consolidation to serve weather, land, and ocean uses.

3. Development of commercial R&D

The EARTHSTAR R&D program will emphasize applied R&D to complement the basic research by the Government. COMSAT intends to place emphasis in several major areas related to the space and ground segments:

- Satellite Data Compression - Techniques to compress the data stream such that less data elements can be transmitted without loss of information;
- Satellite to Satellite Communications - Techniques to relay information from a polar orbiting satellite to a single ground station via geosynchronous satellites;
- Synthetic Aperture Radar (SAR) Sensor Development - Uses of SAR devices for earth sensing;
- Two Dimensional Linear Array Sensor Development - Extension of the linear array device technology;
- Applications Development - Development of advanced applications products to include those related to agriculture, petromining and cartography; and
- Mass Storage/Archive Development - Techniques to store and recall data from an archive in a near real time mode.

Working closely with Government, users and the value-adding industry, COMSAT would develop these and other new capabilities to gather, process, store and deliver data which is not currently obtained by civilian remote sensing satellites. For example, there is a high interest in the petromining, land-use, cartography, and construction industries for high resolution stereoscopic data. COMSAT has developed two designs for high resolution sensors which have been reviewed by NASA Headquarters and the Goddard Space Flight Center. Either of these COMSAT designs would provide stereo products superior to the French SPOT satellite stereo products. Such a system could be flown on the LANDSAT D Prime satellite or on the first EARTHSTAR unique system in the 1987-1990 time period.

4. Development of the commercial markets

Initially, COMSAT will provide standard data products and services to the Government and other users of the type that are currently provided by the Government. COMSAT also will embark on a service improvement effort. The creation of a successful commercial business requires improved product delivery services to all users. The aim of this future service will be to offer all users and value-adding companies flexible, near real time, and retrospective access to compatible weather, land and sea data.

The growth of the services offered by other companies for specialized value-adding processing, interpretation or analysis of satellite data is also important to the success of a commercial system. COMSAT believes that substantial market development will come from data used to provide these specialized, enhanced, or interpretative products. Therefore, it is our intention to foster and support the development of these services and the companies which provide them.

E. CONTRACTUAL ARRANGEMENTS

1. Procurement of data

COMSAT proposes to furnish EARTHSTAR data and services to the Government under a long term contract which would provide the Government with the necessary regulation, flexibility and national security controls. A long term contract would establish, in advance, a pricing formula for the Government's procurement and would provide the necessary incentives for COMSAT to undertake the substantial investment required to initially acquire the Government satellites and develop a commercially viable remote sensing satellite system.

The contract would be under terms similar to a fixed price, minimum quantity, purchase type contract (subject to an inflation escalator) and would also provide for a reduction in price to the Government by a percentage of commercial sales.

Data would be provided by COMSAT pursuant to an agreement with the Government that would protect COMSAT's ability to market the data to other users and would continue the Government's public weather services.

The contract should also include an identification of the requirements of the Government for remotely sensed data products and services, and establish a mechanism for defining future Government requirements and adjusting the contract price accordingly.

The contract should also establish arrangements for required Government control such as directions regarding the acquisition or dissemination of data products for reasons of foreign policy, national disaster, national emergency or national security.

2. Sale of the satellites and related equipment

As explained in more detail in the EARTHSTAR Document and the EARTHSTAR Update, COMSAT proposes to purchase the operating NOAA, GOES and LANDSAT satellites in orbit and under contract at the time of transfer. COMSAT also proposes to purchase GOES and NOAA standard product processing systems, and the operational control center equipment and software. COMSAT would also purchase the LANDSAT D image generation equipment and software. COMSAT proposes to lease the NOAA and GOES data receiving and command stations facilities at Wallops Island, Virginia, and at Gilmore Creek, Alaska, until the centralized EARTHSTAR facility is completed.

F. OVERALL CONTEXT

The overall budget, international and business context of satellite remote sensing has been explained above. The commercial dilemma and the EARTHSTAR solution have also been explained. With this overall context in mind, we will now discuss the detailed issues raised by NOAA and show that none of those issues preclude commercialization of the weather satellites.

III. COMMAND AND CONTROL

> "The broad area of command and control of the civil satellites by DOD is an important consideration. This has three facets: (1) priority service to DOD under either normal circumstances or emergencies (this includes situations that are not publicly-declared national emergencies); (2) denial of civil satellite use to hostile powers (even if that involves destroying the satellites); and (3) transfer of command and control of civil satellites to DOD in emergencies. Although the role of the civil satellites is frequently referred to as that of a backup to the Defense Meteorological Satellite Program (DMSP), the activity is an integral part of DOD weather forecasting and not only a backup. For example, today the civil satellites are the principal source of weather data to the Brisith fleet in the Falklands. Other support involves classified programs, but it should be noted that DOD requirements saturate some satellite modes of operation. A high priority must be placed on those activities and could conflict with the objectives of a commercial venture." (NOAA Issue Paper)

A. PRIORITY SERVICE TO DOD

The Department of Defense has national security related needs for data that require acquisition and delivery by a civilian operator on a priority basis. These needs can and will be satisfied on a priority basis under the EARTHSTAR proposal by virtue of the flexible contractual arrangements which were discussed in Part II above. For example, if DOD wants all the weather data concerning a particular geographic location that can be acquired by EARTHSTAR satellites, that data will be provided by COMSAT. Such requests can be met even if they would saturate the weather satellite modes of operation such as tape recorder capacity on the polar orbiting satellite. Under the EARTHSTAR proposal the Government is the primary customer for weather data, and it may choose the priorities of data acquisition without altering the price of the data. No conflict with potential commercial sales of data would be created because the business would be structured to provide priority service to the Government and data requirements of customers would be subject to preemption if necessary; just as it must be today under Government operation. Further, most commercial customers are located in the United States and interested in regional weather where regional data can be obtained by direct readout without conflicting with tape recorder priorities established by the Government. Communication satellite services are operated by COMSAT on a customer priority basis -- including the Navy's UHF MARISAT service -- and we are experienced in handling such arrangements.

Priority distribution of data to DOD also is not seen as a problem for COMSAT. We intend to establish direct communication links with DOD and the National Weather Service (NWS) for the delivery of weather data. The data would be acquired, preprocessed and delivered to DOD in near-real time according to standards established by contract with the Government. The Government may establish priorities on the preprocessing and delivery of weather data under the arrangements we have proposed. For example, the Government could request that certain data be processed on a priority basis and delivered only to DOD.

Priority service to meet DOD needs would be provided under normal circumstances or emergencies (whether declared or undeclared). Arrangements can be established to meet DOD needs without making either the arrangements or the particular events public. Thus, requirements for data covering a particular area on a priority basis can be communicated and met on a completely confidential basis.

Therefore, priority of service to DOD does not conflict with the objectives of the EARTHSTAR business.

B. DENIAL OF CIVIL SATELLITE USE TO HOSTILE POWERS

The NOAA statement actually involves two separate issues -- the ability to maintain control over the satellite for data collection, and the ability to deny hostile powers access to or use of the data obtained by the satellite. Each will be discussed separately below.

1. Spacecraft Control

The transfer of civil weather satellites to COMSAT would not adversely affect the security of the spacecraft from take over or damage by hostile forces since there is very little existing security in the civil weather satellite control system. The essential elements of spacecraft control are: (1) the physical security of the ground station; (2) the security features of the spacecraft control subsystem; and (3) the security of the communication links. The NOAA satellite ground control facilities are located on Government property but are not secure. The NOAA satellites control subsystems have no security features and the satellites are not hardened. The communication links and, in particular, the telemetry, command and control are not scrambled or secured. Therefore, there should be no objection to transfer of the satellite control functions to COMSAT.

Improved satellite control security is fully consistent with a commercial weather satellite system. For example, COMSAT operates the MARISAT satellites which provide UHF communications to the Navy. The satellite control center at COMSAT corporate headquarters at L'Enfant Plaza is physically secured pursuant to Navy requirements. All spacecraft commands from the control center are transmitted to earth stations by dedicated communication links, and all earth stations have the capability to operate autonomously in controlling the spacecraft in case communications with the control center are interrupted. Similar arrangements can and should be provided for weather satellites.

Additional security could be provided by scrambling the communication link between the control center and the earth stations and upgrading the security at the earth stations as may be required by the Government. It may also be advisable to use SGLS (military) compatible telemetry and control equipment to make the civilian satellite control system compatible with the DOD weather satellite system. Currently, the NOAA and DOD weather satellite control systems are not compatible, and control cannot be transferred easily from one system to the other. Compatibility would provide additional ground system back up for each system. Further security could be provided by "hardening" of future satellites if requested by the Government. COMSAT, in cooperation with the Government, has been studying the feasibility of "hardening" communications satellites.

2. Data control

Hostile forces can be denied use of data either by scrambling the raw data or denying physical access to the data. There is no data encryption on the civil weather satellites and we understand data encryption is not used normally on the military weather satellites. All data downlinks are transmitted in the clear and can be received by anyone equipped with easily obtained equipment in the reception area. Data control in the existing system is limited to the timing of data downlink transmissions so that only persons in a particular area can receive the data and control of the distribution of data received at the ground facilities.

The denial of the use of data to hostile powers (as determined by the Government) would not conflict with the commercial objectives of a commercial civilian weather satellite system since the U.S. Government would be the primary customer for weather data. As stated earlier, COMSAT would comply with requests by DOD to limit the distribution of weather data. This would include restrictions on direct readout from the satellites and distribution of data received at our ground facilities.

For reasons of commercial as well as public security in the EARTHSTAR system, the data downlink on future commercial remote sensing satellites, weather and land, probably will be scrambled using a system employing a changeable key with authorized users receiving the de-scrambling key. At the same time, the data acquisition and satellite control systems of the civil system probably would be made compatible with DOD systems, facilitating take over in extraordinary circumstances (see discussion below) and providing additional operational backup for both systems. These improvements would result in a more secure data control system than currently exists.

Other measures may also be required to prevent a hostile power from obtaining access to sensitive weather data. Satellites could be equipped with lock out or disabling devices if required in the national interest pursuant to the terms and conditions of the Agreement between the Government and COMSAT.

In conclusion, there are no conflicts between the controls required to deny hostile powers use of the satellites and the commercial operation of the civil weather satellites.

C. TRANSFER OF CONTROL TO THE GOVERNMENT

The question raised by NOAA concerning the Government take over of the satellites and ground facilities in emergency situations is adequately provided for under current law. Section 606 of the Communications Act of 1934, as amended, gives the President emergency powers over communications facilities. In such circumstances, the President may

> suspend or amend, for such time as he may see fit, the rules and regulations applicable to any or all stations or devices capable of emitting electromagnetic radiation . . . and may cause the closing of any station . . . or he may authorize the control of any such station . . . by any department of the Government under such regulations as he may prescribe upon just compensation to the owners . . . .

U.S. civil remote sensing satellites would be subject to these provisions since radio communications are used to control the satellites and to relay data to earth.

To the extent that DOD needs to take over the satellites and ground facilities in the event of a national emergency, such take over could be facilitated by making the DOD and the civilian TT&C and data links compatible as discussed earlier. The transfer of control of remote sensing satellites in a national emergency does not conflict with the commercial objectives, but is a necessary requirement of doing business which exists for COMSAT's communications satellite operations as well.

D. SUPPORT TO CLASSIFIED PROGRAMS

We understand that the classified programs referred to by NOAA involve the interpretation or use of weather data as opposed to the acquisition, preprocessing or delivery of weather data to the NWS or DOD. COMSAT does not propose the transfer of any Government operations involving the interpretation or use of weather data. Therefore, the commercialization of the civil weather satellites should not affect in any way classified programs involving the processing or interpretation of weather data. DOD and other national security organizations which use weather data in classified programs would continue to receive data as they do now. The Government data users would not notice any change when the system is transferred from NOAA to COMSAT.

IV. FLEXIBILITY AND RESPONSIVENESS

> "Flexibility and responsiveness must be retained in the complex interrelationships that exist between the defense and civil systems. Satellites are only one element, although an important one, of an overall weather observing and forecasting system. Optimization of that system involves control and modification of criteria for satellite replacement (i.e., what instrument failure, or combination of instrument failures, necessitates satellite replacement), orbital parameters (to fit the needs of synoptic analyses), and satellite instrument complements. The civil and military systems currently share the use of the same polar orbiting satellite design and are implementing interlocked shared data processing systems. The Government must control the above items -- particularly such critical parameters as the equator crossing time of a polar orbiting satellite, which could conflict with some aspects of commercial operation." (NOAA Issue Paper)

A. INSTITUTIONAL FLEXIBILITY

As is apparent from the discussion above regarding command and control, and the requirements listed by NOAA under this issue, a number of both informal and formal arrangements can be established to provide the President with the controls necessary to maintain national security and to meet the other priority needs of the Government. These arrangements must, of necessity, be flexible and responsive to accommodate both foreseeable and unforeseeable requirements and events. None of the flexibility and responsiveness in the relationships between DOD and NOAA would be lost by or inconsistent with the transfer of the civil weather satellites to COMSAT. It goes without saying that it is in the commercial interest of COMSAT to be fully responsive to the needs of its principle customer -- the U.S. Government. Therefore, we believe that arrangements between COMSAT and the Government can be made which not only retain but also build on the flexibility and responsiveness which now exists in the relationships between DOD and NOAA.

Furthermore, the relationships which now exist between the defense and civil systems need not be disturbed by commercialization. Through contractual and operational procedures, COMSAT, as the civil satellite owner and operator, would interact with DOD without disturbing the "complex interrelationships that exist between the defense and civil systems." Therefore, neither the flexibility and responsiveness nor the relationships between the systems would conflict with commercial operation.

B. SATELLITE SYSTEM DESIGN AND SATELLITE MISSION CONTROL

The civil weather satellites provide essential data for defense and civil weather forecasting systems as well as backup for the defense satellite system. Therefore, it is essential that the civil satellite system provides data that meet the needs of the DOD and NWS weather forecasting systems. However, Government management of satellite design or control of the satellite mission is not essential to meet the data needs of either DOD or NWS. The data needs of the defense and civil system can be satisfied by establishing data requirements to be met by the commercial entity. All the necessary elements, such as criteria for satellite replacement, orbital parameters, new data, combination of data, etc., can be provided by contract.

The requirements of DOD and NWS which must now be satisfied by NOAA would, in the future, be satisfied by a commercial operator. In fact, commercial design and procurement practices could be more flexible and timely in meeting Government data needs than interagency relationships. A more detailed discussion of the requirements and how they would be met follows.

1. Satellite replacement

Arrangements would need to be established to determine when additional satellite launches are required because of an inability to deliver a particular data set or a combination of data sets caused by an instrument or satellite failure. COMSAT is very familiar with the concepts and preparation of satellite replacement and sparing plans. Such plans will be necessary in any event for a commercial operator to define satellite failure in purchasing insurance.

2. Orbital parameters

Since the defense meteorological model requires a sampling from low earth orbit every four hours and the defense meteorological satellite system even when fully operational, will not provide enough samplings (only four samples in a 24 hour period); it is essential that one of the civil weather satellites fly an orbit that will provide the missing samples. The civil weather forecasting system also may have requirements for particular orbits. However, these needs do not require Government management of the system. Data specifications, including orbits, will be an essential part of a procurement contract. Performance of the Goverment contract is not in conflict with a commercial operation but is the essence of the EARTHSTAR service.

3. Satellite instrument complements

The NOAA Issue Paper implies that it is necessary for the Government to make the management decisions with regard to which instruments or complement of instruments should be flown. However, Government management is not necessary. The Government needs can be met by definition of the data requirements Government and COMSAT would agree on the specifications of data to be delivered, given the planned or existing facilities and satellites. Specifications for new data which require new instruments or facilities could also be agreed to, from time to time, taking into account the lead time required and additional costs, if any. While the engineering and technical decisions regarding choice of instrumentation are the primary responsibility of the commercial owner and relating to the ability to provide an economical, efficient and reliable service, COMSAT would review equipment decisions with the Government if so requested. COMSAT believes the Government would benefit by the shift of the technical system and subsystem design decisions from the Government to the private sector in efficiency, economy and design innovation, but if the Government wished to specify use of particular equipment, COMSAT would be happy to comply as long as the additional costs, if any, are borne by the Government.

4. New Data

The introduction of new sensors and technology to meet NWS and DOD requirements also should be provided for by establishing procedures for accommodating new technologies, including a mechanism to adjust data prices to the Government when the costs of obtaining such data increase with no corresponding increase of commercial revenue. Arrangements could also be made for joint projects involving experimental sensors and technologies. COMSAT intends to introduce new sensors and technology and has developed a program for their orderly introduction. Operational civil satellites also could occasionally carry experimental sensor packages for NASA or DOD. COMSAT does not see the introduction of new technology as being inconsistent with commercial operation; rather it is an absolute necessity for maintaining a productive system. The subject of long range research is further discussed in Part V, LONG RANGE RESEARCH.

C. SHARED SATELLITE DESIGN

The statement in the NOAA Issue Paper that the civil and military systems share the use of the same polar orbiting satellite design is somewhat misleading. It would be more accurate to say that they both use the same satellite bus. Many of the subsystems and all of the sensors are different. Further, as already discussed, the civil and military systems are incompatible in the two most important areas -- command and control and data downlink. The use of the same satellite bus is a requirement that could be satisfied very easily by COMSAT. The important requirements are that the civil and military data are compatible, and that the essential data needs of each system is met by the other. These requirements would not conflict with a commercial operation.

D. INTERLOCKED SHARED DATA PROCESSING SYSTEMS

The implementation of the "Memorandum of Agreement on the Shared Processing of Satellite Data" between NOAA, the Navy and the Air Force poses no hurdle to the commercialization of the civil weather satellites. The coordinated data and product distribution system and the data processing backup provided pursuant to the Agreement would not be disturbed by transferring the civil weather satellites to COMSAT.

V. LONG RANGE RESEARCH

"Continuing long-range research is essential for the improvement of day-to-day operations. The evolution of meteorological sensors is necessary if capabilities in weather forecasting are to advance. Experience suggests that the evolution of new instruments and their integration into defense, civil, and international forecasting regimes is a lengthy, complex process. The new geostationary sensor called the "VAS" is being brought currently from experimental development to operational use. The process of scientific research and development of the instrument and its experimental utilization has gone on for nearly a decade, and several more years will be required before it is routinely used in the National Weather Service. Ongoing research areas that will lead to operational instruments include advanced microwave sounders and coastal zone color scanners. The steps between research and the operational use of new systems involve three distinct phases: (1) the establishment of requirements by operational entities that determine the direction of research and development, (2) an evaluation phase, carried out in the operational environment by the operational people, to assess the utility of the new technique or system, and (3) the decision, based on technical and economic considerations, whether to proceed to full operational deployment. Each phase could produce conflicts with the objectives of a commercial venture." (NOAA Issue Paper)

A. STATUS OF LONG RANGE RESEARCH

NASA should continue its basic and long range weather research. Commercialization of the operational weather satellites should not affect the continuation of such research. Further, COMSAT intends to supplement NASA research efforts with our own research.

In the Western world, the U.S. leads in satellite remote sensing science and technology, in particular with regard to weather satellite remote sensing. This leadership is a result of the scientific research and sensor developments led by NASA and the DOD. There is no known public foreign threat to our leadership in weather satellite remote sensing technology. However, continued long range research is essential not only to maintain U.S. technology leadership but to provide improvements in weather forecasting, warnings, modeling and services.

Most of the funds currently being invested in advanced weather satellite research and development come from the Department of Defense. NASA also has a modest, but very successful, weather satellite R&D program which, unfortunately, has been dropped from the FY83 Budget. Whether NOAA or NWS picks up this R&D effort is not yet certain. Traditionally, DOD, NOAA, and NASA have cooperated in the weather satellite field with NASA developing devices for DOD and NOAA, using both DOD and NASA R&D money. Private investment in weather satellite R&D is minimal.

The NOAA Issue Paper suggests that commercialization of the weather satellites would adversely affect the development of the U.S. weather satellite technology and science base. COMSAT believes this is incorrect. Defense expenditures for R&D must and will continue independent of any decision to commercialize the civil system. Since DOD is a primary source of R&D expenditures, the U.S. technology lead should continue. Technology transfer from classified to unclassified systems will continue subject to existing policy objectives and controls on the classification of technology, thereby benefiting the civilian weather programs.

The EARTHSTAR program also assumes a strong NASA basic science R&D program and would expect that a portion of the net savings to the Government, which are possible through the EARTHSTAR program, would be dedicated to such a program consistent with the current policy of the Administration.

In addition, COMSAT would embark upon its own sensor R&D program at a funding level approximately the same as would be spent by NASA (currently around $6 to $7 million) and there should be no substantial difficulty in coordinating COMSAT R&D efforts with the Government.

Further, commercialization of the civil weather satellite system would stimulate additional R&D by the manufacturers of spacecraft and remote sensing systems, subsystems and components, who would be bidding to supply the commercial operator. Since R&D investment is, to some extent, a function of revenue, the R&D investment for data analysis and interpretation would also increase as the markets for remotely sensed data, including weather data, are developed.

Commercialization of the weather satellites would not detract from existing R&D efforts and would actually stimulate weather satellite research and development to the benefit of the nation.

B. EVOLUTION FROM RESEARCH TO OPERATION

The NOAA Issue Paper suggests that the steps in the evolution from research to operation "could produce conflict with the objectives of a commercial venture". While some conflicts could, of course, be produced, such conflicts would be insignificant. On the whole, the process would benefit greatly from commercialization.

1. Establishment of requirements

For example, the establishment of customer requirements is a classical commercial function to determine the present and future needs of the customer and to determine how they best can be met. The commercial incentives involved in developing new products and services (and therefore the devices to produce such products and services) are very strong. Given these incentives, a commercial entity is likely to perform this function better than a Government entity.

2. Evaluation

The assessment of new instruments or systems is also a function which could benefit by commercialization. In order to satisfy existing and future Government requirements for data, COMSAT would be developing, on a continuous basis, new instruments and system components. Before being brought into service, these instruments and components must meet the strict requirements for reliability, efficiency and utility which COMSAT requires in all of its commercial equipment.

3. Operational deployment

Equipment which can be used to meet the data needs of COMSAT's Government or non-government customers efficiently and reliably will be put into operation in the EARTHSTAR system. Since both the Government and COMSAT would be concerned with the same requirements (reliability, efficiency, utility) COMSAT foresees no conflict between the interests of COMSAT and the Government.

VI. REGULATION

> "Commercialization of the weather satellites as perceived could necessitate the formulation of a complex regulatory regime to protect the Government's interests in weather services. The constraints that would be imposed by defense, civil, and international considerations might create a captive entity with no flexibility to act as a private enterprise. . . ." (NOAA Issue Paper)

Commercialization of weather satellites need not require a complex regulatory regime. The Government's interests can be protected fully in the contract between the Government and the data supplier.

A comprehensive, long term contract, as described in Part I above, would provide the necessary arrangements as to price performance, quality, flexibility and national security control. For example, during the negotiation of the contract price, the Government will have access to COMSAT's costs. The price of data would be negotiated to provide an expected return on investment acceptable to both the Government and COMSAT. The long term nature of the contract also will provide the Government suitable protection against cost increases.

COMSAT also proposes that the contract provide for reducing the Government's price each year by a formula tied to the growth in non-Government sales as a proportion of total sales. This will provide the Government as well as COMSAT an incentive to maximize the commercial sales. If the commercial markets develop more quickly than anticipated, both the Government and COMSAT will share the rewards. Such an arrangement would provide an incentive to the Government to allow the development of commercial markets for weather data. For example, the Government could allow COMSAT to take over the distribution of GOES and NOAA imagery which has a large commercial value to television weather organizations such as the new all-weather cable TV channel. On the other hand, the contract would specify data which the Government requires to be made public.

Further, the protection of the Government's interests does not require constraints that would result in the lack of flexibility to act as a private enterprise. The EARTHSTAR proposal is designed to ensure that all essential Government interests are satisfied but, without jeopardizing such Government interests, to maintain the flexibility to develop a truly commercial integrated civil remote sensing satellite system which will improve products and services, immediately lower Government expenditures and develop the markets for remotely sensed data, domestically and internationally.

VII. THE NET EFFECT OF COMMERCIALIZATION

If the potential commercialization of the weather satellite systems is assessed in terms of the overall effect of commercialization on system management effectiveness, efficiency, cost and benefits, COMSAT believes that a decision to commercialize is indicated.

Compared to the administrative cost and effort involved in transferring the NOAA, GOES, and LANDSAT activities, the commercialization of the weather and land satellites, as proposed, has enormous potential benefits to the Government. COMSAT has shown in the EARTHSTAR Document (December 14, 1981) and EARTHSTAR Update (March 15, 1982) the Government could achieve savings of as much as $600 million over the first five years and of at least $80 million each year thereafter by procuring remotely sensed weather and land satellite data from COMSAT. The commercialization of the weather satellites would provide for the development of commercial markets for weather satellite data that can result in further price reductions to the Government. The commercialization of the weather satellites would provide for the full utilization and development of the environmental data relay system which remains largely unused under Government management. The commercialization of the weather satellite systems would achieve continuity of service in that the full two polar orbiting satellite system would be provided at less cost. It also would relieve the budget pressures which required NOAA to request that the European Space Agency provide part of the future civil weather satellite coverage. Further, it is COMSAT's intention to create an integrated remote sensing satellite system that would be more efficient, productive, and responsive to users than either the current separate weather or land satellite systems. The commercialization of the weather satellites could provide all these substantial benefits while safeguarding essential Government interests.

This demonstration of benefits of commercialization far exceeds the requirements of existing Government policy for determining when an activity should be commercialized. Generally, the policy, as set forth in Office of Management and Budget Circular A-76, is that an activity should be commercialized unless it can be demonstrated that (1) there are no satisfactory commercial sources available; (2) Government operation is required for reasons of national defense; or (3) Government operation can be shown to be cheaper than private operation. None of these factors have been demonstrated by the Government. On the other hand, COMSAT has shown that (1) a satisfactory commercial source can be created; (2) Government operation is not required for reasons of national security; and (3) private operation would be considerably cheaper than Government operation. Therefore, we believe that commercialization of the weather satellites is required under existing Government policy.

The NOAA Issue Paper implies that there is some unexplained conflict between the "public service" requirements of the Government and the transfer of the weather satellites. As shown, there is no such conflict. "Public services" are derived from the Government's use of data, not the management or operation of the remote sensing satellites. Data provided by COMSAT to the Government would continue to be used to provide "public services". In fact, improvements which COMSAT can achieve in the satellite system will help the Government to provide better services to the public.

VIII. CONCLUSION

COMSAT believes that this response supports the conclusion that none of the issues raised in the NOAA Issue Paper should preclude commercialization. The prospect of commercialization has also been examined from a larger, management and system perspective and such examination demonstrates that the benefits of commercialization far outweigh the normal administrative costs of commercialization. COMSAT has also shown that commercialization of the weather satellites is required under existing Government policy. For these reasons, COMSAT respectfully requests the Administration to promptly initiate a process for the transfer of the civil weather and land remote sensing satellites to the private sector by adopting a policy of commercialization in the FY84 Budget and including funds for its implementation.

CONSIDERATIONS FOR TRANSITION
OF THE
CIVIL OPERATIONAL REMOTE SENSING FROM SPACE

A
WHITE PAPER
BY
CONTROL DATA CORPORATION

CONTROL DATA CORPORATION

CONTROL DATA

8100 34th Avenue South
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October 19, 1982

John H. McElroy
Assistant Administrator for Satellites
National Earth Satellite Service/NOAA
Washington, D.C. 20233

Dear Mr. McElroy:

Control Data Corporation's interest in the transition of "Civil Operational Remote Sensing" to the private sector is motivated by our commitment to the user communities affected by the transition. That commitment is manifested by our fundamental business strategy; that is, identifying segments of the marketplace as targets for our products and services. These segments become target industries and we develop our products and skills to support them.

Today, we have six (6) target industries: Energy, Environment, Petroleum, Mining, Education, and Manufacturing. The Agricultural industry is on the threshold of becoming the seventh. All but Manufacturing are directly involved with applying data gathered by your remote sensing systems. Specific experience with remotely sensed data processing and distribution include:

- At our Houston Data Services Center we provide products and services for mining and petroleum exploration, aerial photography, LANDSAT data and seismic processing.
- Our systems process weather and other atmospheric data at centers such as NOAA, NASA-Goddard's Laboratory of Atmospheric Sciences, NOAA's Geophysical Fluid Dynamics Laboratory, Fleet Numerical Oceanographic Center and several international weather centers.
- Our CDC-McIDAS system for image processing is used by meteorological Centers to process geosynchronous satellite data.
- We were program teammates with Rockwell International for the National Oceanic Satellite System (NOSS). Our responsibilities included input to systems level definition, requirements analysis and total ground segment requirement specifications.

John H. McElroy
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The mechanism for accomplishing this transition, as directed and implied by the RFI and the findings of the government's Advisory Groups, clearly indicate the need for a full system that is an end-to-end approach to the problem. Control Data is fully supportive and concurs with the necessity for such an integrated, all-encompassing transition plan. Our direct involvement with user communities and state-of-the-art participation with the DOD in the evolution of next generation space systems clearly reinforces our support for fully integrated space and ground solutions.

In this context, however, Control Data contributions to this process can only become substantive as part of an integrated end-to-end program. Control Data does have meaningful inputs at the system level as related to specific user community requirements and tolerances.

Based upon the above considerations, Control Data has elected to submit the attached white paper which deals with the transition in terms of business and marketplace considerations, as opposed to the substantive technical details called for in the RFI. Our understanding of the formal evaluation process established by the government indicates that these data may more appropriately be evaluated by your Land Remote Sensing Satellite Advisory Committee rather than becoming part of the formal evaluation process.

By virtue of our corporate commitment to the target industries identified above, Control Data intends to remain involved in this process at both a systems level, in terms of affecting the process, and at a more detailed level as part of a consortium or cooperative venture by industry.

As part of this effort we would welcome an exchange of ideas with NOAA. We look forward to a mutually beneficial relationship in a most challenging venture.

Sincerely,

CONTROL DATA CORPORATION

W H Bruning

Walter H. Bruning
Vice President, Data Services
Systems and Services Company
Control Data Corporation

Enclosure: White Paper

WHITE PAPER

ON

CIVIL OPERATIONAL REMOTE SENSING FROM SPACE

Control Data Corporation

October 1982

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3.0 TRANSITION OF WEATHER SATELLITES

1.0 INTRODUCTION

Control Data Corporation's views and comments on "Civil Operational Remote Sensing from Space" are specifically tailored to emphasize the non-technical business aspects of transition to the private sector.

Control Data contends that the success or failure of any transition plan of the government's remote sensing programs to industry is contingent upon achieving a viable and self sustaining business entity as the initial goal of the ultimate transition effort. Although the technical aspects of the transition represent real and formidable challenges, no new or unproven technologies should be required to meet the vast majority of user requirements. The real untested and, therefore, "high risk" aspect of the transition is the viability of the marketplace that must support the resulting business venture.

The aggregate direct market value and intangible value of remotely sensed data has been estimated in numerous studies and analyses. They are largely based upon existing methods of collection, distribution, and general availability to the public. The sensitivity of this marketplace to conversion from a service-based operation to a profit-based operation is the fundamental issue in question.

The establishment and validation of that marketplace must, therefore, be an integral part of the transition planning and its ultimate execution. Further, many of the technical details of the later phases of the transition, and the extent to which the transition can profitably be conducted, will remain speculative until a validated marketplace is clearly established.

The following comments are provided as a summary of Control Data's principal concerns in effectively transitioning these capabilities to the civil sector.

1.1 Market Fragmentation

Users of environmental data and services (e.g., LANDSAT, weather, oceanography) have traditionally been an extremely diversified and fragmented community. Attempts by government and industry to make a detailed compilation of user-by-user requirements and ability to pay for these services, have been less than successful. Most studies are based upon extrapolations of detailed regional or spot samplings used to infer the nationwide and worldwide market potential.

The community at large recognizes the utility and worth of integrating these data sources into its operations, but as individuals are hesitant to make the investments required to fully exploit the data or insure its continuity. Further, individual users of the data resist adopting a generalized (productized) solution to their problem in deference to a tailored or special purpose solution. Even within the government sector, the application of these data are spread across state, local, municipal, federal, and regional boundaries and interests, making it difficult to efficiently market well-defined products and services to a particular geography or user base.

In summary, Control Data does not question the aggregate value of the marketplace for LANDSAT data and products. However, based upon direct experience, we question the accessibility of that marketplace to a concerted penetration of sufficient magnitude to support the total operating costs of a LANDSAT or similar business operation.

1.2 Market Protection

Considering the massive non-recurring and recurring operating costs necessary to establish an operational satellite program, it is difficult to envision a transition scenario other than in a near monopolistic environment for the data collection and value added processing and distribution functions.

Independent ventures may exist to service highly specialized applications. For example, a petroleum or mining company may contract for a shuttle or sortie launch of a large-format camera to support a specific, short duration project. However, the broad based, day-to-day support to the general user community must come from an equally broad based and extensive operation that can provide a wide range of services and product options on a continuing and reliable basis. The system costs, therefore, will continue to be very heavily weighted in the satellite development, operations and data recovery segments.

The nature of the resulting business must be one that permits the company to amortize these costs across the largest possible user base. An environment which permits an intermediary company to gain access to these data without incurring the recovery costs, and redistribute these products and services to other end users, adversely impact the competitive balance of incurred costs and revenue.

The remotely sensed data marketplace would be similar to the TV cable networks or videotape industries which rely heavily on copyright laws and regulations to protect the value of the purchased products.

The immediate affect of imposing such regulations would be to undercut a significant number of existing intermediary companies which rely on the relatively free and easy access to these data as a basis for providing tailored products and services to end users. The longer range effect of these regulations would be the encouragement of a very large consolidated venture, significant economy of scale advantages, and the lowest possible end user cost. However, it would promote a monopolistic or near monopolistic business climate.

1.3 International Impacts

As with domestic regulations, an international climate needs to be established that not only preserves the value of the data in the international marketplace, but encourages the integration of multinational data sources into the overall process to provide the end users with the widest possible range of products and services.

One possible scenario would have the company(ies) in our country serve as brokers for distribution and sale of foreign products to domestic based end users, and its foreign based counterparts act as brokers for the distribution and sales of U.S. products to their respective end users.

This form of arrangement could be established through international trade agreements and/or corporation-to-corporation marketing agreements.

1.4 Business/Market Direction

It is imperative that the commercial entity be structured such that it can establish its overall direction and make business decisions based primarily on user derived needs and requirements. The tendency in a high technology environment is often contrary to this basic premise. The vast majority of the projected users for these data, and therefore the market segment that must be considered first, do not require significant technological advances over currently projected capabilities.

In this context, the business direction must come from the commercial entity which directly services the user community and establishes the market requirements.

The resulting corporation or consortium should serve as a vehicle for technological advancements and support specialized higher technological user requirements, but should not be expected or encouraged to amortize these costs across the entire user base. To do so would potentially jeopardize the support and viability of the primary user base.

1.5 Data Fusion

Mid and long range projections for advances in remote sensing technologies indicate that significant emphasis should and will be placed on merging multiple data sources to:

- Yield more accurate direct physical measurements.
- Infer additional indirect physical characteristics.
- Improve overall operational performance.

1.6 Weather Systems

Many mature LANDSAT users currently use weather data to augment or improve their use of LANDSAT data. The trend is for increasingly elaborate mergers of these two data sources by more and more of the user base. In the LANDSAT transition timeframe, the LANDSAT data processing system should have real time or near real time access to geosynchronous and/or polar orbiting weather satellite data.

1.7 Technology Considerations

Remote sensing programs within the government, particularly in the civil portions, were initially driven by technology. This approach resulted in great progress in space and sensor technology. Commercialization of any program will dictate that advances in technology be driven by the marketplace. Thus, it may be necessary for the government to look at alternatives to any lack of technology advances on the part of a commercial enterprise. Alternatives include:

- o Retention of technology advances within the government.

- Separate and distinct ventures with commercial entities for advancement such that they do not impact on the current business operations. In the latter case, special care must be taken such that there is no real or perceived cost of technology advancement borne by the other customers.

Further, as new technologies are developed, other than user driven, business considerations would determine whether they are incorporated into the commercial entities operation. If this is of concern to the government, some arrangement must be made jointly to accommodate this concern.

2.0 RECOMMENDED APPROACH

The concerns and observations presented in the previous section are largely based upon our corporate understanding of the user communities that would be expected to support the proposed transition. Having been formally committed to these user communities (Mining, Petroleum, Environmental, Energy, Education and Agricultural) for the past decade, and as a corporation that intends to continue that commitment as a vehicle for profitably marketing its products and services, Control Data Corporation believes that an effective transition of these programs to the private sector can occur. The two key prerequisites, however, for an effective transition are:

- A "user driven" market, system definition and organization.
- A well defined, yet finite, government sponsored transition period (legislative/regulatory support, risk sharing and technical).

2.1 Phased Approach

Control Data's general recommendation is that the government consider a phased approach to accomplishing the transition. The first phase would be a cooperative venture by government and industry to operationally validate the mechanisms for the transition from subsidized, service-based operation to a product based, "for profit" operation. This would be implemented in the form of a LANDSAT USER SERVICE CENTER that would perform the current Goddard and EROS data processing and distribution functions in a commercial environment. That is, working in cooperation with the government, the center would firmly establish and commit a user base (private, government and international) capable of absorbing the full costs for operating the current LANDSAT system. The center would not only serve as a vehicle for establishing the fair and reasonable market value of these products and services, it would begin defraying the current government subsidies of these services. The center would accomplish many critical functions in support of a full transition to the private sector, including:

- Defining user requirements and ability to pay for technological advancement.
- Through quantitative evidence, determine the viability of transitioning the flight segment to the private sector.
- Analyze the utility of alternate data sources and platforms.

A center could be operational by early 1984 and have validated outputs and an established user base by late 1984. A realistic goal would be to have firm industry commitments to the takeover of all government financial obligations by late 1985 and all government operational responsiblities by late 1986.

2.2 A Candidate LANDSAT User Service Center

Control Data has defined and designed several satellite data processing centers for both the weather and LANDSAT user community. Further, we have implemented our own Remotely Sensed Data Users Service Center in Houston, Texas. Coupling this experience with that of providing the largest worldwide data service network, we present a candidate system to help achieve the phased approach discussed in paragraph 2.1 above. The functions of the center would include:

- Data Conditioning--calibration, navigation, interpretation, quality control and archiving.

- Powerful and Rapid Data Processing--data analysis, data fusion, generic product generation and tailored industry oriented application products.
- Photo Lab--tailored photographic products.
- Service Center Consultants--training and consulting compliment for "total solution" productization.
- Administrative and Distribution Departments.

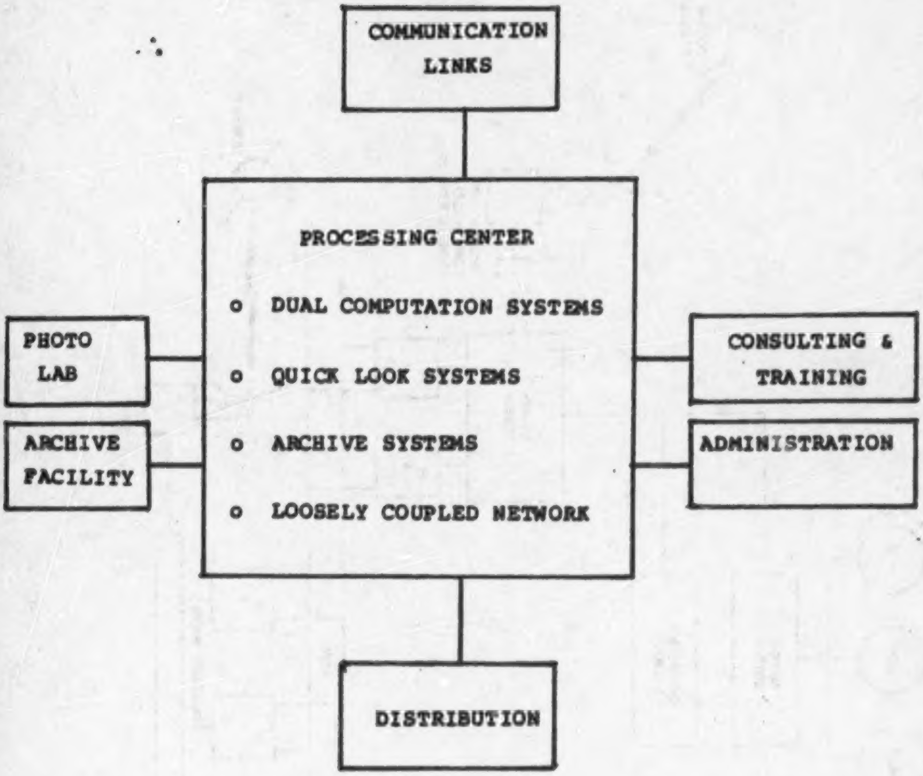
The schematic, Figure 1, represents the candidate center. The schematic of the data processing functions is represented in Figure 2 with more detail shown in Figure 3.

Conceptually, the LANDSAT data will be received by the primary earth station (still under government responsibility) which exercises the tracking, telemetry and command/control functions. At this point, high density tapes are generated and the data simultaneously sent via DOMSAT or terrestrial microwave to the LANDSAT User Service Center. The earth station or microwave terminal at the processing site would pass the data streams to two host processors by way of a local area network called the LCN (Loosely Coupled Network) which is capable of a 50 Mbps rate. The interfaces to the network are shown in Figure 2 as Network Access Devices, NADs. Also shown in Figure 2 is an envisioned interface for geostationary weather satellite data. Other polar orbiting satellite data would be acquired in a sister intefface system similar to the LANDSAT interface shown.

The candidate LANDSAT User Service Center hardware, software, and operation rough order of magnitude costs are summarized below (these ROM costs do not reflect cost sharing):

o	One-Time Costs--Includes special hardware, software, antennas, photo lab, site preparation and installation.	$10M
o	Annual Lease Costs--Includes computers, software, maintenance, power, and facilities.	$ 3M
o	Annual Personnel Costs--Includes three shifts, seven days per week, consultants, administration, and distribution.	$ 8M

It appears that the present revenue which the government receives from their customers, if transferred to the processing and distribution company, would pay for the annual costs of the center described.


COMMUNICATION LINKS
PROCESSING CENTER
o DUAL COMPUTATION SYSTEMS
o QUICK LOOK SYSTEMS
o ARCHIVE SYSTEMS
o LOOSELY COUPLED NETWORK
PHOTO LAB
ARCHIVE FACILITY
CONSULTING & TRAINING
ADMINISTRATION
DISTRIBUTION

CANDIDATE LANDSAT USERS SERVICE CENTER
FIGURE 1

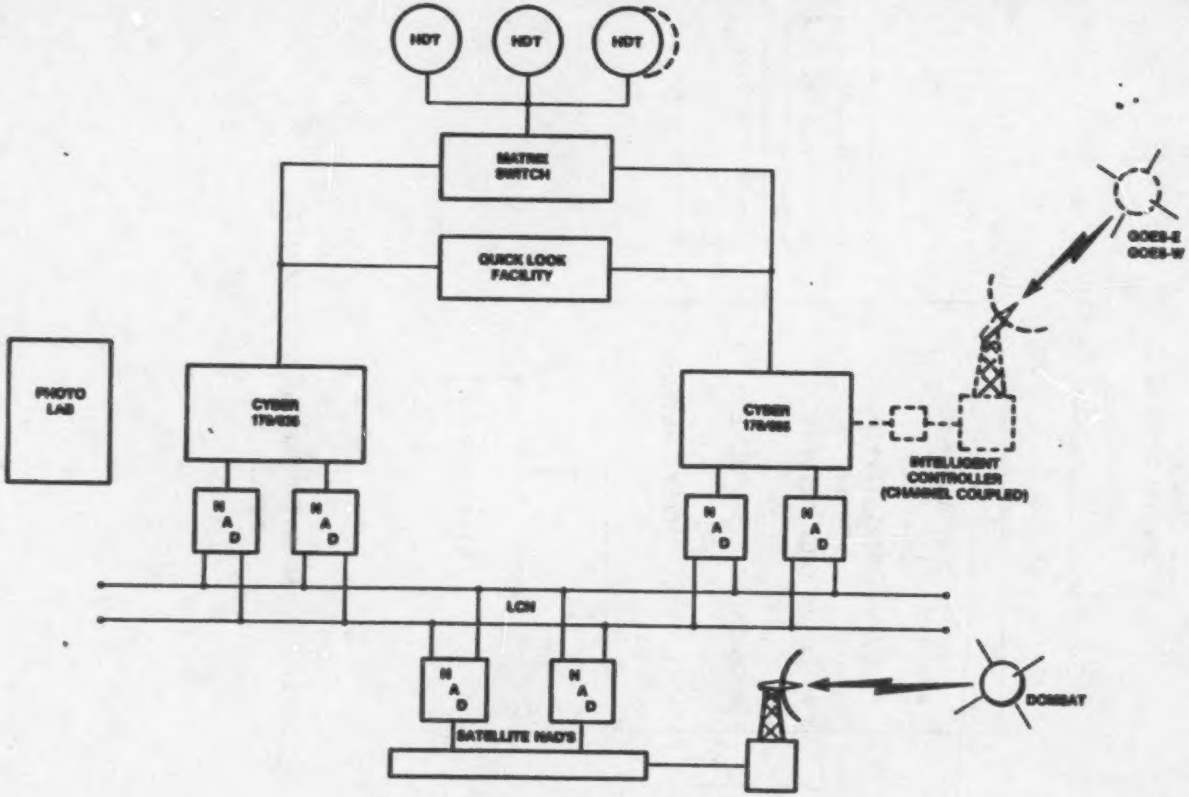

HDT
HDT
HDT
MATRIX SWITCH
QUICK LOOK FACILITY
GOES-E
GOES-W
PHOTO LAB
CYBER 170/835
CYBER 170/855
INTELLIGENT CONTROLLER (CHANNEL COUPLED)
NAD
NAD
NAD
NAD
LCN
NAD
NAD
SATELLITE NAD'S
DOMSAT

Figure 2

CYBER 170/MODEL 855
COMPUTER SYSTEM

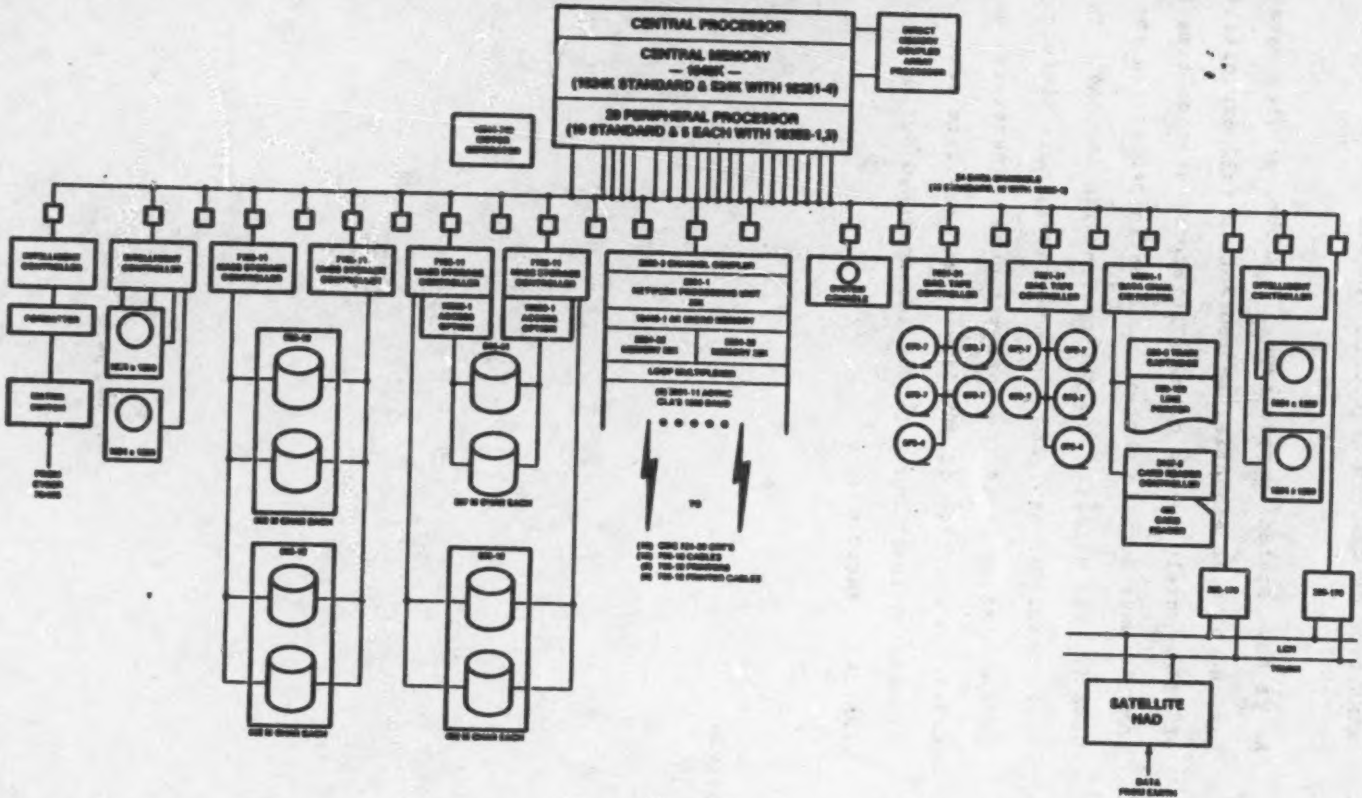

CENTRAL PROCESSOR
CENTRAL MEMORY
20 PERIPHERAL PROCESSOR
CHANNEL COUPLER
NETWORK PROCESSING UNIT
LOOP MULTIPLEXER
SYSTEM CONSOLE
MAG. TAPE CONTROLLER
MAG. TAPE CONTROLLER
LINE PRINTER
CARD READER CONTROLLER
CARD READER
INTELLIGENT CONTROLLER
INTELLIGENT CONTROLLER
INTELLIGENT CONTROLLER
MASS STORAGE CONTROLLER
SATELLITE NAD
DATA FROM EARTH STATION

Figure 3

3.0 TRANSITION OF WEATHER SATELLITE SYSTEMS

As we have stated in paragraph 1.5 above, we view data fusion to be an essential ingredient to full exploitation of all remotely sensed data. Therefore, at some time the LANDSAT User Service Center would begin processing the data for use directly and for fusion with LANDSAT. This would result in new, and, in some cases, more useful products and enlarge the customer base. Therefore, an orderly transition of NOAA's weather satellite data processing functions could be accomplished during the LANDSAT transition.

September 17, 1982

Dr. John H. McElroy
Assistant Administrator for Satellites
National Earth Satellite Service, NOAA
Washington, DC 20233

Dear Dr. McElroy:

ESD

ESD has been told unofficially that NOAA will soon formally request information from the private sector on the possibility of commercializing certain NOAA operations. With this in mind, we are submitting an unsolicited proposal for the next logical stage in the acquisition, the processing, the dissemination, and the use of environmental satellite data. Our overall intent is to present our position as a preliminary open discussion with the management of NOAA/NESS. With them, we wish to explore the future in order to agree on a course of action.

Our proposal is based on successful operating experience, rather than theoretical analysis; on facts, not conjecture. Moreover, it is in accord with the stated policies of the current Administration and with OMB policies established earlier and confirmed by the current Administration. If implemented, it will free NOAA from the necessity of devoting its resources to workaday functions that can be carried out by private industry. Instead, NOAA can focus its attention on exploring new frontiers in weather satellite technology and operations.

To make this possible, we can offer the government both significant cost reductions and improvements in products and services related to weather satellite data. In fact, we will be pleased to contribute information from precise studies to A-76 cost analyses without obligation to the government.

You may use any of this information freely to consider plans for some of the NOAA operations. However, since much that is contained in this proposal is proprietary and confidential, we ask that the contents of this proposal be circulated only among those who will be involved in analyses, discussions, and evaluations.

Environmental Satellite Data, Inc.
World Weather Building
5200 Auth Road
Suitland, MD 20746
301/423-2113

Page 2
Dr. John H. McElroy
September 17, 1982

We are eager to answer questions and to furnish amplifying information, either formally or informally. Requests for such information and for appointments to discuss the principles that will serve as the basis for specific action, can be made by calling this office. We look forward to hearing from you.

Sincerely,

Terry C. Hambrick

Terry C. Hambrick
President

IN THE INTERESTS OF TRADITIONAL FREE ENTERPRISE

In some respects, government must be maternalistic when "doing for" its citizens and businesses. But when the time comes, government must permit the fledgling to fly on its own.

ORIENTATION

There are well-established precedents for federal agencies providing useful new services to the American public and to American businesses and industry. But there are also precedents for later ending governmental provision of services that private industry can supply without sacrificing efficiency or quality. In many cases the changeover is accomplished through government contracting; in other cases the government simply discontinues a service that has become available through commercial channels. In still other cases a hybrid system is installed, wherein the government contracts with a private firm to operate a government facility as a concession, returning a portion of the profits to the government.

Based on the OMB Circular A-76, comparison studies of the costs of federally operated functions versus the costs of contracting out such functions have demonstrated that the private sector can provide many services at a lower cost than federal agencies can. Often, these arrangements even return income to the government. This is especially desirable today when there is so much need to reduce government spending and at the same time stimulate the economy. Both our national dedication to free enterprise and practical considerations dictate that the private sector assume responsibility for the provision of goods and services whenever possible.

GENERAL PREMISES

Environmental Satellite Data, Inc. (ESD) believes that the time has come for private industry to assume responsibility for processing and distributing weather-satellite data for both government and commercial uses. Our successful supplying of services and products to broadcast meteorologists and others has demonstrated the feasibility of private sector involvement in weather satellite processing and distribution.

Environmental Satellite Data, Inc.
World Weather Building
5200 Auth Road
Suitland, MD 20746
301/423-2113

(Distribution authorized to the internal government committee and the Land Remote Sensing Advisory Committee for their review function only).

Since 1981, ESD has offered processed satellite data of higher quality and greater utility to the media than that which is available from the federal source. The enthusiastic reception of our product is persuasive evidence that a company such as ours can flourish to become an established enterprise, despite competition from a government product provided to the user without direct cost. A consideration of the achievements of ESD shows rather clearly that the following are valid premises:

1) A market exists for more highly processed weather-satellite data.

2) The market is willing to pay for such data.

3) Private industry is capable of meeting the demand.

CONCLUSIONS

On the basis of the premises stated above and in the tradition of free enterprise in the United States, it appears evident that the government need no longer process and distribute weather-satellite data free of charge at the taxpayers' expense. ESD can relieve the taxpayers and NOAA/NESS of the burden of providing such data.

We are convinced that ESD can assume the responsibility for the processing and the distribution of certain weather-satellite data and that we can do so more effectively and economically than current government operations can. The specific operations that ESD proposes to assume are GOES-TAP and VISSR Image Registration and Gridding System (VIRGS). The plan we present in these pages serves not only our interests but the interests of the American economy. Its acceptance will promote the substantial growth of an infant industry and ultimately benefit the nation.

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II

BACKGROUND: REVIEW AND EXPLANATIONS

> A new and valuable industry has been born, and NOAA can nourish it and accelerate its growth, to everyone's benefit, including its own.

BASIC BRIEFING

For those who are unfamiliar with GOES-TAP and VIRGS, the following will provide background information.

The GOES-TAP Service

GOES-TAP is a service provided by NESS, a subagency of NOAA, that distributes weather-satellite data to the Weather Service Forecast Offices (WSFO) and various other organizations. Started in 1974, GOES-TAP now has several hundred users. Non-federal users are both non-profit and for-profit organizations, including industrial and commercial organizations and universities. Roughly one-half of these are for-profit operations, such as commercial broadcasting systems, airlines, public utilities, consulting firms, commercial meteorologists, and weather forecasting services.

GOES-TAP has a Central Data Distribution facility in the World Weather Building at Suitland, Maryland, plus a network of leased telephone lines and switching systems at Satellite Field Service Stations (SFSS) in six cities in the United States.

The overall system costs several million dollars annually to operate. All costs are borne by NOAA/Department of Commerce. Among the principal cost centers are those for leased telephone circuits, for contracted operations and maintenance services (GE-MATSCO), and for NOAA's own management staff. Non-government users of the service pay a fee to the telephone company for a telephone circuit link to the system and a nominal fee to the government for the initial hook-up.

Unofficial sources have reported that NOAA plans to institute a monthly charge to compel external users to pay for what has been an essentially free service. We believe that it is entirely reasonable to require for-profit users to pay for a service with an obvious cash value for them. Indeed, many of these users have shown a willingness to do exactly that. In only fourteen months, ESD has built a clientele of more than ninety users of ESD's value-added satellite data at an average monthly cost of $800 to each user. We believe that ESD can provide a superior service to GOES-TAP users for a reasonable fee. This fee will be substantially more cost effective than the one cited above because of the attendant increase in volume.

Confidential and Proprietary to ESD - 3

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The VIRGS Operation

Also operated by NESS, VIRGS is a standalone system that supplies earth-location information to the Wallops Island Command and Data Acquisition Station. This system processes data from the satellite data stream and then returns it to the Synchronous Data Buffer where it is appended to the Satellite's data stream in a round-robin procedure. In the current operation, VIRGS determines the satellite's orbit and attitude to an accuracy of 10 full-resolution visible pixels, requiring a full day after the maneuvering of the satellite to do this. In contrast, ESD can provide GOES earth-location information to an accuracy approaching one pixel within six hours after the maneuvering of the satellite.

ESD is uniquely qualified to substantially improve the current VIRGS system for two fundamental reasons: our staff includes professionals who are especially expert in the GOES earth-location function, and ESD must install its own system for making these determinations as a matter of economic necessity -- our service demands a superior product. Thus, the new system will be installed and operated at ESD's own expense in the near future. Therefore, ESD will be in an excellent position to supply commercial and government organizations with superior earth-location data.

Since the interfaces between NESS and ESD for the GOES earth-location function will be quite easy to define, implement, and control, ESD will provide the earth-location data at an annual cost that will represent a substantial saving for NESS. Moreover, ESD will provide a better product, one that will feature greater accuracy achieved in a much shorter time. Precise estimates of costs and savings will be furnished at the request of NOAA/NESS.

AN OVERVIEW OF ESD

ESD is a pioneer with the vision to recognize the long range potential and the ultimate value of weather-satellite data. Incorporated in 1980 for the purpose of supplying easily accessible GOES Satellite data products to the commercial user, we have built an economically viable enterprise that supplies processed satellite data of higher quality and greater versatility than the GOES-TAP data which NESS provides without charge.

ESD GOALS

ESD launched its venture with the goal of providing satellite imagery for a wide variety of weather-related activities and continues to pursue that goal. Moreover, we are convinced that we have barely scratched the surface of the true potential of this industry. We are committed to expanding our service to satisfy the needs of aviation, agriculture, shipping, off-shore drilling, and research, among many others. We have already identified thousands of potential users who can and will pay for weather-satellite data

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tailored to their specific needs. We do not doubt the immediate future will see a vast increase in the useful applications of this data, properly enhanced through digital processing. Nor do we doubt that such data will exert a profound influence on the industrial progress of the United States.

We believe that ESD will be a catalyst and forerunner of an important new industry and that we will be responsible for major reductions in the costs of weather-satellite data, both directly and indirectly. Without question, the example of ESD in pioneering this new industry and in demonstrating its acceptance and commercial viability will be followed eagerly by others.

IMPLICATIONS

Unquestionably, NOAA and NESS have been pioneers in the development and the use of environmental satellite data. Their achievements probably could not have been brought about by private industry. Yet, the continued existence of GOES-TAP has a negative effect on both NESS and ESD. NESS is committed to designating a significant percentage of its budget to GOES-TAP operations. Ironically, NWS and others base their budgets on the assumption that GOES-TAP will go on indefinitely. As a result, GOES-TAP is forced to continue in operation, thereby creating a chicken-egg paradox. The new industry that ESD represents is also hindered in its development, for users are discouraged from paying for more exact and useful data because they receive a free service, subsidsized by NOAA.

Despite ESD's success, the number of users subscribing to our service is not now great enough to enable us to institute the lower prices that inevitably result from large-scale use. If the competition from free data is removed, ESD can guarantee that the increased number of subscribers will result in more cost-effective pricing. The overall result will be the growth of an important new industry.

This will directly benefit NOAA/NESS. If ESD's long-range goal to expand its present services and to stimulate the development of new services is realized, it will become unnecessary for NESS to provide the GOES-TAP or the VIRCS services. NESS can then turn its attention to activities for which it has demonstrated greater expertise than any other organization.

NESS OPERATIONS

Currently, there are four main functions of NESS:

1) Command and control of environmental satellites and acquisition of data from them.

2) Processing and distribution of data.

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3) Data interpretation.

4) Research on new applications of satellite data.

SUMMARY

We believe that ESD and others in the industry can assume the second function described above. Because our efforts have direct commercial applications, we can afford more sophisticated and more expensive processing to produce a more valuable product. This is an everyone-wins situation: the government reduces costs and could even gain revenue; users receive more effective and more useful products; and a new industry is encouraged and stimulated, thus creating new jobs and expanding the GNP accordingly. As an auxiliary benefit, ESD and other members of this new industry will increase national interest in satellite data and thereby function as vehicles for increasing the community of users for NOAA satellites.

It is time to recognize that, from this point forward, the efforts of profit-oriented private industry will accelerate progress. This will benefit the nation through expanded use of data for more than government programs. At the same time, it will free tax monies for services that the private sector cannot provide.

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III

THE SPECIFIC PROPOSAL

> We believe that ESD can implement the general philosophy discussed earlier and, with NOAA, give the necessary impetus to the development of an important new industry.

THE PROPOSAL

ESD proposes to assume responsibility for GOES data processing and distribution from NOAA, thus providing a product of greater utility and value at a significantly lower cost than GOES-TAP now provides.

We further propose to assume responsibility for the GOES earth-location function from NOAA, thus providing a better product at a significantly lower cost than the VIRGS system now provides.

PRELIMINARY STEPS

We recognize that several alternatives exist and that the proposed changes may take time to bring about. We are also aware that a gradual phaseover of GOES-TAP and VIRGS to private industry may be necessary, possibly with an intermediate contracting out of the system's operation to ESD. We realize that many questions must be raised and discussed. We think that the details of the phaseover need not be addressed in this preliminary paper, but rather across the conference table. Thus, this paper is intended only to outline the basic idea and to act as a foundation for beginning discussions.

We have already had several discussions with other interested parties--the General Accounting Office, for example. These meetings have encouraged us to present this proposal. We believe that the next logical step is to exchange the ideas connected with it. After agreements have been reached, we will offer a detailed proposal based upon our mutual interests. For the moment, we request only that we have the opportunity to meet the proper NOAA officials to discuss the ideas presented in this paper.

A SUGGESTED SEQUENCE OF EVENTS

1) ESD will offer NOAA a detailed, comprehensive draft of a plan to retire the free GOES-TAP service. Suitably programmed to permit all users to adjust to the upcoming situation, the plan will include details of ESD's proposal for expanding the users and the availability of processed GOES data throughout the government and the commercial communities.

2) ESD will offer NOAA a comprehensive plan to assume the VIRGS service on a contractual basis.

3) Once the plan has been reviewed, discussed, and adjusted to suit all parties, NOAA can then announce the phaseout of the free GOES-TAP.

4) ESD will begin immediate implementation of the plan agreed upon to provide a fully operational system.

SUMMARY OF MAIN POINTS

1) NOAA/NESS has broken ground for the government, bringing about truly enormous improvements in meteorology, and it now has dependable working systems in place.

2) Private industry, pioneered by ESD, has taken the torch from NOAA/NESS and has introduced commercial improvements. Equally important, ESD has demonstrated conclusively that private industry is ready, willing and able to take over so that the government can turn its attention to more pressing needs.

3) ESD has found it necessary to duplicate and to improve upon a number of NOAA/NESS functions, including the VIRGS GOES earth-location process. As a result, we can perform these functions more precisely and at a lower cost than NESS can.

4) ESD can free NOAA from the obligation to provide free data or to sell data. Moreover, ESD proposes to provide improved services to NOAA/NESS on a contractual basis and to help NOAA reduce costs and avoid impending investment.

5) ESD wishes to expand the services that the growing number of our users has demonstrated as viable. To this purpose, we propose to assume responsibility for the operation of GOES-TAP and of VIRGS. We therefore request a meeting to seriously discuss these prospects and the future of a vital, new industry.

GENERAL ELECTRIC
COMPANY
SPACE SYSTEMS DIVISION
VALLEY FORGE SPACE CENTER
P. O. BOX 8555 PHILADELPHIA, PA. 19101

October 21, 1982

A. J. ROSENBERG
VICE PRESIDENT AND
GENERAL MANAGER

Dr. John H. McElroy
Assistant Administrator for Satellites
National Earth Satellite Service/NOAA
Washington, D.C. 20233

Subject: Civil Operational Remote Sensing from Space

Dear Dr. McElroy:

I welcome the opportunity provided by the Land Remote Sensing Satellite Advisory Committee to express the General Electric Company's view on commercialization of civil remote sensing systems.

In testimony before Joint Senate and House Subcommittee Hearings in July 1981, I indicated that the land remote sensing system was not ready for private sector takeover, primarily due to the insufficient definition of the market to sustain a private venture. Over the past year, I have seen no fundamental change in the environment which would encourage responsible private sector investment. No spontaneous market growth has occurred nor have market development activities been initiated. Further, the critical issues, so ably summarized in your comprehensive September 1982 review, remain largely unresolved.

Since the government's intention to commercialize the civil remote sensing program was first announced, General Electric has reviewed the issues in depth, considered various scenarios for potential commercialization, and testified on several occasions. In each case, we determined that commercialization of remote sensing faces significant obstacles, resulting in unacceptable business risk. A premature push into the private sector before a formidable array of issues have been resolved and a proven market is shown to exist has high inherent business risks. On the other hand, a failure to continue Landsat will allow subsidized foreign competitors to step in and serve the market, foreclosing U.S. private sector involvement in the future. Therefore, continuation of Landsat under government sponsorship is imperative to protect the $1 billion investment made to date in this key program and to permit eventual private sector involvement if it proves economically feasible in the future.

Dr. John H. McElroy
October 21, 1982
Page 2

The Landsat-4 system has been in operation for over three months. Based on data received to date, we sense the same kind of excitement and enthusiasm that accompanied the initial data results from Landsat-1. The Landsat program continues to perform as a significant national asset.

I encourage the Administration to follow through on international cooperation as expressed in the U.S. Space Policy Statement and UNISPACE '82 discussions. I believe that international cooperation in remote sensing programs can result in lower cost to participating countries, and a sharing of the worldwide benefits that the Landsat system has come to exemplify. I once again recommend that the government evaluate its important role in the Landsat program and recognize the positive and beneficial impact that a commitment to data continuity for land remote sensing could have on the commercialization process.

Sincerely,

COMMERCIALIZATION OF UNITED STATES CIVIL REMOTE SENSING SATELLITE SYSTEMS

OCTOBER 1982

HUGHES

HUGHES AIRCRAFT COMPANY
SPACE AND COMMUNICATIONS GROUP
EL SEGUNDO, CALIFORNIA

HUGHES AIRCRAFT COMPANY
SPACE AND COMMUNICATIONS GROUP
909 NORTH SEPULVEDA BOULEVARD
EL SEGUNDO, CALIFORNIA

ALBERT D. WHEELON
SENIOR VICE PRESIDENT AND
GROUP PRESIDENT

PLEASE ADDRESS REPLY TO:
P. O. BOX 92919
WORLDWAY POSTAL CENTER
LOS ANGELES, CALIF. 90009

21 October 1982

Honorable Malcolm Baldrige
Secretary of Commerce
Department of Commerce
14th Street between
Constitution Avenue and
E Street, NW
Washington, D. C. 20230

Dear Mr. Secretary,

Hughes Aircraft Company is pleased to submit its views regarding commercialization of the civil remote sensing satellite systems of the United States. This submittal is in response to your request in the 10 September 1982 Commerce Business Daily entitled, "Civil Operational Remote Sensing from Space." I hope the enclosed material will be of positive assistance to you as you conduct your deliberations on this subject.

Sincerely,

Albert D. Wheelon

Enclosure

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4.	Conclusions	14

1. INTRODUCTION AND SUMMARY

Two issues are being considered by the Secretary of Commerce:

(1) What is the best mechanism to implement the current policy of transfer of civil land remote sensing systems (Landsat) to the private sector as soon as possible?

(2) Should the Administration consider simultaneously private sector transfer of both civil weather and land remote sensing systems?

To assist in the consideration of these issues, the Secretary has requested "views and expressions" from private industry. The objectives are to determine the feasibility of the Government issuing an RFP for obtaining the services currently being provided by all or parts of these systems, and to establish the appropriate ground rules for such an RFP and associated competition.

The current request of industry is the result of many years of debate. Years during which no clear consensus has emerged regarding the desirability or feasibility of commercializing our civil remote sensing satellite systems. Hughes has participated in this debate, largely through Congressional testimony and other transmittals to Government agencies. The Hughes position has been one of general encouragement of the Government's efforts to determine if transfer conditions suitable to both the Government and private industry could be established.

It is now clear that at present such conditions could be established for the GOES and TIROS weather systems only at considerable risk to both Government and industry. The risk to Government would be possible disruption of a critical service, plus encouragement of an unwise private capital investment policy. The risk to industry would be one of questionable financial viability. As currently envisioned by the Government, the transfer of Landsat to the private sector would involve no risk or obligation to the Government, but considerable financial risk to any prospective private operator.

It is the position of Hughes Aircraft Company, detailed in the following sections, that ownership of the United States civil land and weather satellite systems should remain within the U.S. Government for at least the next 10 years.

While Hughes does not espouse transfer to the private sector of our civil remote sensing systems, if an attempt at such a transfer were to be deemed appropriate by the Government:

(1) The Landsat, TIROS and GOES systems should be considered separately, and on their own merits. Each of these systems has its separate national mission to perform. Orbital characteristics, instrument complement, and operational characteristics, plus mission criticality, differ for each system. Upon close examination the combining of the management and operations of these missions does not appear practical, beyond that which NESS is currently implementing with the GOES and TIROS weather systems.

(2) Selection of any potential service contractor should be based on a competitive process, and

(3) No monopoly grant to a Government-chartered institution should be considered. A non-competitive monopoly grant or Government charter to a given entity would nullify most of the potential benefits possible through commercialization. With no competition there would exist no impetus for operating cost reduction or increased efficiency. Regulation would amost certainly ensure a "utility"

approach to business. Market development would not be emphasized. One monopoly would be substituted for another. The customer would remain the same.

(4) An operational agency such as NOAA would be appropriate to operate these systems until such time as transfer to the private sector was determined to be appropriate.

The Secretary of Commerce has requested specific inputs regarding each of the U.S. civil remote sensing satellite systems. It is not the intent of this paper to address each of these points in detail. Rather, it is the intent to examine the overall issues from both a national policy and economic point of view. Conclusions are partly based on analytical processes and partly based on subjective judgment, befitting the scope of the question. This response also acknowledges a familiarity with the GOES weather system which exceeds that of the Landsat system and greatly exceeds that of the TIROS low altitude weather system.

2. THE GOES AND TIROS WEATHER SYSTEMS

Major Issues

Should the Government consider the transfer of the GOES and TIROS weather systems to the private sector? What would be the requirements? This section summarizes the major issues involved in this possible transfer. Many interrelated economic and policy factors are involved. Most would appear to render transfer of GOES and/or TIROS services to the private sector difficult procedurally and financially. However, this is not to say that this task could not be accomplished if the Government decided, as a matter of policy, that these services were to be obtained from private industry.

Delegation of Vital Services. Should the Government consider delegation of authority to private industry to own and operate our vital weather systems? These systems have well-defined missions involving national security, national protection against loss of life and property, and long standing international cooperative agreements incorporating cost-free data exchange. Serious thought must be given to the possible consequences of service delays or service default (not necessarily due entirely to the contractor's actions), unforeseen cost increases, and inhibition of required technology advances. The Government has presently begun to contract through industry for critical space-based services (Leasat, TDRS). The success of these early experiences is yet to be determined. It has become clear, however, that risk to both Government and contractor will exist in arrangements such as these. The contractor assumes a considerable cost risk. The Government assumes cost risk plus the risk of loss of service. Contractor and Government committment and integrity are absolutely essential.

Industry Efficiency. One of the justifications given for transfer of the GOES and TIROS systems to the private sector is "private industry can do it a lot cheaper and more efficiently." This may be, however it is not immediately obvious that these cost savings and increased efficiency would be significant.

In fact, these systems are today designed, manufactured, launched, and operated to a large extent by private industry personnel under Government contract and supervision. Competition for these contracts is fierce. They are almost without exception awarded to the lowest bidder. Thus, most of the major functions involved are currently already being performed in a fairly minimum cost, high efficiency mode. This appears to be more particularly true of the weather services than of Landsat, due to Landsat's experimental status.

It is true that industry could possibly save costs by reducing "paperwork" and eliminating some of the "non-profitable" functions the Government performs with regard to these systems (basic research, etc.). Hughes doubts if the magnitude of these potential cost savings exceeds 20%. Even that estimate may be high in light of the relatively low cost operation Hughes has observed in NESS which includes combined operations of the GOES and TIROS weather systems to the maximum extent possible. Further efficiencies might be possible through combining the operations of the very similar TIROS and DMSP systems. However, this issue was not addressed in this study.

System Costs. The total acquisition and 10 year operations costs for a commercial GOES system would be approximately $1.3 billion ($FY 83). This system would require an organization of some 400 personnel to operate and manage. The operator of this system would require a yearly revenue of close to $200 million/year ($FY 83), just to break even financially. Approximately $500 million ($FY 83) of private financing would be required. These requirements are currently beyond the means of most major companies.

The total acquisition and 10 year operations costs for a commercial TIROS system would be approximately $1.7 billion ($FY 83). This system would require an organization of some 300 personnel to operate and manage.

The operator of this system would require a yearly revenue of close to $300 million/year ($FY 83), just to break even financially. Approximately $700 million of private financing would be required. These requirements are also currently beyond the means of most major companies.

Inflation and interest history over the service contract life will heavily influence system costs (and profits). An error of 5% in estimated future inflation rate (e.g., between 10% and 15% inflation) and interest rate could result in a 35% error in estimated system costs over the operating lifetime. These factors are today impossible to predict or control by industry, and perhaps the Government. This uncertainty would have to be accommodated in a service contract by either indexing or escalation clauses, or by the contractor making a conservative estimate and reflecting this estimate in his price. Indexing clauses would nullify a major attraction to the Government of service contracting: Uniform and predetermined payments over the service period. Conservative estimates regarding interest and inflation could result in artificially high costs to the Government, violating another desire: Low cost. Lack of indexing or escalation clauses could result in anything from a large windfall profit to a huge loss for the private contractor. These conflicting factors would be difficult to resolve.

What are the current prospects of a private contractor meeting his costs (much less making a profit) given the revenue requirements above? The current NESS budget for GOES (∿ $80 million), if given to industry in exchange for GOES services, would leave a ∿ $120 million/year deficiency in private revenue requirements for operating this system. A perhaps more "typical" GOES budget equivalent to a GOES G, H procurement period (∿ $110 million) would still result in a ∿ $90 million/year shortfall in revenue. A similar revenue deficiency range for the TIROS system would be ∿ $200-250 million/year.

Could the non-Government commercial market make up this short fall? There is currently no significant commercial market for weather data. It is doubtful a significant non-U.S. Government market would ever emerge. The most likely answer for the weather systems is "No." A long-term Government purchase agreement, covering essentially all investment and operational costs, would be required to make this venture economically feasible.

Monopoly Grants and Guaranteed Markets.

These tend to nullify any differences between a Government agency operating a system for itself, and "private industry" operating the same system with the Government as its sole or major customer under the guise of "free enterprise". One monopoly is substituted for another. The customer stays the same, possibly paying higher costs due to financing costs and profit.

Tax Incentives. As a rule, these do not result in lower net cost to the Government. It is true, with tax incentives individual program costs are reduced, and these savings are passed on to the customer agency. However, the U.S. Treasury receives roughly the same amount less in tax revenues as the individual agency has "saved." The net result is roughly the same cost to the Government with or without the incentives (the time value of money can result in some net gain or loss for either side).

Private Capital Investment. At a given point in time, there is only a fixed pool of private capital available in the United States. At the present time, this fixed pool of private capital is quite limited. Investment of this limited national resource would be best applied to areas which are of national criticality, including heavy machinery, production lines, new technology, and industrial facilities. Diversion of a significant amount of this private capital to reacquire systems which are already operating, and which most likely would never product a profit or a significant exportable product, does not seem like a wise national policy.

A solution often suggested is for the Federal Finance Bank (FFB) to finance these large projects. However, the FFB was clearly not established to accommodate or manage projects of this size or with the economic characteristics of a major space system. Its one experience of this kind (TDRS) has made this abundantly clear. Also, the Government finances the FFB through savings bonds, T-bills, etc. Whether it pays industry to finance its commercial debt, or pays bond holders directly for its own Government interest debt, the Government is still financing the systems and operations.

Regulatory. Regulation would be required in several areas: Pricing, data distribution, and data rights policy would have to be established consistent with equitable access to and utilization of data by Government, commercial and international users. Regulated prices would also have to reflect true costs of data acquisition to the system operator.

Competition might have to be regulated due to the nature of a commercial weather system. The operator would be functioning much as a utility does, and might require a similar combination of competitive constraints and protection.

The system operator may require regulation to comply with existing and new international agreements reflecting data access, distribution, and price. Finally arrangements would have to be made to permit the DoD to assume priority over data acquisition and distribution in times of emergency, with appropriate consideration being given to the effects on the system operator's business posture.

Legislation: The Department of Commerce (DoC) would require authority to procure and regulate a commercial GOES or TIROS system. In order to be commercially viable, the data provided by this system may require exemption from the Freedom of Information Act. In order to avoid potentially huge financial penalties and risk, a commercial operator would most likely require indemnification against claims involving loss of life or property. The DoC could require authority to commit to a long term purchase agreement. If the Government wanted to minimize yearly costs for GOES or TIROS service, it could choose to begin payments in advance of service. This would require legislative authority. Finally, tax incentives for potential owners/operators might have to be incorporated into existing tax laws.

Technology Evolution. Space based systems are by their very nature high technology. This technology must be nurtured and advanced. Technology improvements are obviously greatly facilitated in a non-cost constrained environment. A fixed cost, long term, monopolistic arrangement for the operation of our remote sensing systems would obviously not encourage the technology evolution required to remain current in capability. This problem is currently sufficiently severe within Government. For instance, in the last ten years, only one significant technological improvement has been made to the GOES satellite system (the addition of sounding capability). Technology advances in the TIROS and Landsat systems have been equally as constrained.

Transitioning Through Partial Commercialization. It has been proposed by interested parties that commercialization of our remote sensing systems take a phased approach. That is, initial assumption of only ground segment operations or space segment operations, followed by gradual assumption of the operation of the remainder of the system(s). This would have the advantage of lower capital requirements, plus allow time for a private contractor to acclimate to system operations. Initial operation of a system ground segment is most often mentioned in this regard. It is the opinion of Hughes that if this approach were to be taken, then a space segment should also be considered as the initial portion commercialized. The justification for selecting a ground segment revolves around cost and hoped-for market development. Theoretically a ground segment operator would be more motivated to develop data markets aggressively than would a space segment operator. Also, ground segment costs are supposedly lower than space segment costs, facilitating entry into this arena by industry.

The great preponderance of the GOES and TIROS data market is and will remain almost entirely the Government. Commercial market development by either a ground or space segment operator would have only marginal impact on economic viability. The Landsat commercial data market has been pursued very aggressively by many entities for many years. Significant commercial success for any of these entities is not evident. Again, the Government is by far the major market for this data. Market development will product only marginal additions to this market. There is also no reason why a space segment operator would not pursue market development as aggressively as a ground segment operator. One is a supplier, the other a distributor. Both would have the goal of increased data sales.

Initial acquisition costs of space segment hardware most often do exceed those of associated ground systems. A space segment would be more difficult financially for a private operator to implement. However, this higher cost may be offset by more operating ease in a political sense. A space segment operator would be concerned only with spacecraft command and control, data sensing, and data readout to his Government customer. These functions would involve minimum regulation and control by the Government. A ground segment operator would have to be concerned with the issues of data pricing, data distribution, data rights, international agreements, foreign policy, and others involving much more comprehensive regulation and control. These factors could make initial operation of a ground segment much more difficult operationally than initial operation of a space segment.

Ground and space segments should each be considered as candidates for initial commercialization, in the event that any commercialization becomes feasible.

3. THE LANDSAT SYSTEM

Major Issues

Should the Government transfer the Landsat system to the private sector? The issues involved are basically the same as those for the GOES and TIROS systems, with notable differences as discussed below.

Delegation of Vital Services. The Landsat system, as opposed to the weather systems, does not provide a critical service to the country. It performs no national security function (at present resolution levels). Landsat data does not contribute directly or in a time critical manner to national protection against loss of life and property. It has no national or worldwide infrastructure dependent upon it for data. Landsat does serve as a valuable adjunct or alternate to traditional methods of national and state renewable resource management (crops, water, etc.) and to non-renewable resource exploration (oil, minerals). It is this non-criticality which makes this service easier than the weather systems to commercialize from the Government's point of view. This same non-criticality makes this service more difficult to commercialize from industry's viewpoint.

The Government can afford to experiment with commercialization of Landsat because no significant national financial consequences would result from failure of this attempt (assuming no long-term comprehensive purchase commitment is made). Failure of a commercial Landsat venture would not diminish the Government's ability to fulfill its public or international commitments in any way. If a commercial Landsat venture were to succeed the Government would have the satisfaction of having been omniscient and very generous to American industry, plus could profit considerably from the development of this new national capability.

The same factors mentioned above as favorable to the Government would be unfavorable to industry. Industry would require a long term comprehensive data purchase agreement plus a national "mission" or charter, plus other forms of assistance (regulatory, international) to support a commercial Landsat operation. The fact the Government has alternate (less expensive?) means of performing the tasks which Landsat is amenable to could mean an unwillingness to consider providing such an agreement (especially incorporating the data prices required to support such a system), a national "mission," or other assistance. Without these Governmental assurances, a commercial Landsat operation would be very difficult to implement profitably.

System Costs. The total acquisition and ten-year operating costs for a commercial Landsat system would be approximately $2 billion ($ FY 83). An organization of approximately 400 personnel would be required to operate and manage this system. The operator of this system would require a yearly revenue of close to $300 million/year ($ FY 83) just to break even financially. Approximately $700 million ($ FY 83) of private financing would be required. As discussed in Section 2, inflation and interest uncertainties could alter these financial requirements considerably. The financial requirements mentioned above are currently beyond the means of most major companies.

What are the current prospects of a private contractor meeting his costs (and making a profit) given the revenue requirements above? The current NESS and NASA Landsat budgets (∿ $70 million), if given to industry in exchange for Landsat services would leave a deficiency of over $200 million/year in revenue requirements for operating this system. A perhaps more "typical" Government budget equivalent to a Landsat continuity decision (∿ $150 million) would still result in over a ∿ $150 million/year shortfall in yearly revenue.

Could the non-Government commercial market make up this short fall? As opposed to the weather systems, there is a commercial Landsat market. Worldwide data sales are expected to be ∿ $20 million in 1983. Even with this commercial market, the total revenues available to pay for Landsat services still falls far short of requirements. This situation will continue to exist for the foreseeable future.

Regulation. In addition to the items discussed for the weather systems, regulation of the operator with respect to competition may be required. Systems such as the French SPOT intend to sell their Landsat type data on the world market. The extent to which these systems will be permitted to cooperate or compete within the United States must be resolved.

Ground resolution and direct foreign data read out may require regulation in order to conform to national security and foreign policy standards.

4. CONCLUSIONS

GOES AND TIROS WEATHER SYSTEMS

It is the current stated policy of the U.S. Government that ownership of the GOES and TIROS weather satellite systems should remain within the Government. Hughes Aircraft Company believes this should remain policy for at least approximately the next 10 years. Conditions amenable to commercialization of these systems do not appear forthcoming within the foreseeable future.

The civil weather satellite systems missions (TIROS, GOES) embrace national protection against loss of life and property, national security, and maintenance of long standing international agreements. These are traditionally recognized as Government roles. There is no domestic or foreign policy impetus for private industry to assume these functions. Financial analysis indicates that industry would have difficulty espousing this transfer on a sound business or efficiency basis. The regulatory conditions required to make assumption of this vital service by private industry feasible would in all likelihood defeat the purpose of the transfer and eliminate the potential benefits. The weather satellite system should remain under Government ownership for at least approximately the next ten years.

If the U.S. Government should determine that commercialization of the GOES and TIROS systems is desirable, then:

(1) The GOES and TIROS systems should be considered individually and separately, and on their own merits.

(2) Selection of any potential service contractor should be based on a competitive process.

(3) No monopoly grant to a Government-chartered institution should be considered.

(4) An operational agency such as NOAA would be appropriate to operate each system until such a time as transfer to the private sector were determined to be appropriate.

LANDSAT

It is the stated current policy of the U.S. Government to transfer civil land remote sensing satellite systems (Landsat) to the private sector "as soon as possible". Industry has been asked, "What is the best mechanism to accomplish this?" It is the position of Hughes Aircraft Company that this will not be an easily implementable policy at any time in the foreseeable future. Nor, perhaps, should it be.

The main utility of Landsat data is to the Government. By its very nature, Landsat data lends itself to applications which are global in impact: Non-renewable resource exploration, world agriculture monitoring, etc. The Government's desire to place this program in the private sector appears to stem not from a desire to achieve cost savings or increased efficiency. It does not seem to stem from a belief in not competing with industry, or other industrial growth policy. It seems to stem from the simple fact that the U.S. Government believes it has alternate, less expensive, means of accomplishing the tasks to which Landsat data is applicable. Landsat is surplus to the Government.

Be that as it may, there seems to be no valid economic, regulatory, political, or foreign or domestic policy impetus for private industry to assume the ownership of the Landsat system, other than an unsubstantiated belief in extraordinary future commercial market growth which would make it viable. This unsupported belief is not sufficient justification for the investment of the large amount of resources required.

The results of this study indicate that the fate of Landsat is best left within the Government. Industry and Government have done their utmost over the past several years to try to arrive at a set of conditions which would benefit both sides. These conditions are not forthcoming, without serious compromise of both Government policy standards and good business management practices.

If the U.S. Government should determine that commercialization of the Landsat system is desirable, then:

(1) The Landsat system should be considered separately, and on its own merit.

(2) Selection of any potential service contractor should be based on a competitive process.

(3) No monopoly grant to a Government-chartered institution should be considered.

(4) An operational agency such as NOAA would be appropriate to operate this system until such a time as transfer to the private sector were determined to be appropriate.

OCEAN ROUTES

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CABLE OCEANROUTES SAN FRANCISCO

October 15, 1982

Dr. John H. McElroy
Assistant Adminstrator for Satellites
National Earth Satellite Service/NOAA
Washington, D.C. 20233

Dear Dr. McElroy:

The following comments are in response to the Secretary's Request for Information published in the Commerce Business Daily on the subject of Commercialization of the Civil Space Remote Sensing System.

OCEANROUTES is the leading ship weather routing company in the world and also the leading private supplier of meteorological information to the offshore oil industry worldwide.

In general, I am very much in favor of reducing the Government's role in our economy and increasing the role of private enterprise. However, I am very strongly opposed to the concept of transferring the weather satellites to the private sector.

It does not make sense to transfer the weather satellites to the private sector. My reasons are outlined below:

1. Although free enterprise and the profit motive do lead to efficient methods of operation, civil sector weather satellites would not be operated under our free enterprise system. Clearly a monopoly situation would be created.

2. Since the government would be the predominant user of the data (95%), and since the government would require a continued flow of this data, it is obvious that government guarantees would have to be given to the civilian satellite operator to make sure that that operator remains financially viable. At that point the free enterprise spirit would be destroyed.

3. Since the civilian operator would sell satellite weather data to civilian sources, and because a monopoly situation would exist, it is obvious that the civilian operator would have to be heavily regulated especially in prices. The price would not be set by market forces (their being no alternate supply), but rather by an arbitrary regulated formula. This is objectionable.

4. There is an important precedent set by the United Nations and the World Meteorological Organization which have operated under the philosophy that the weather data collected by national governments should be available to any user at no cost other than perhaps local communication costs.

5. Having a private sector weather satellite operator does not make sense in light of the large amount of inter-agency coordination required for weather data, especially with the military weather systems.

ABERDEEN HONG KONG HOUSTON LONDON NEW YORK PERTH SINGAPORE TOKYO

6. The leading contender for the job of private sector manager does not have a successful track record in private enterprise activities. I can find no justification in the argument that a private sector manager could collect satellite data and sell it at a profit.

7. The present system appears to be working quite well. To change this system would require an enormous amount of money which does not appear to be recoverable in any way.

In summary, I believe that it is a valid role for government to collect and disseminate weather data. This includes satellite sensed weather data. I can find no justification for creating a "private enterprise" to handle the collection and dissemination of this data when, in fact, that private enterprise will have to be regulated, run as a monopoly, and have complete government subsidization and guarantees.

OCEANROUTES is enormously interested in seeing continued and dramatically improved remote ocean sensing capability for the United States. We stand prepared to fully support the NROSS concept and, in fact, I believe that a capability beyond that presently suggested for NROSS is necessary.

I would be pleased to provide more information and am available at any time to discuss further the commercialization of the weather satellites.

Yours truly,

Fritz Snideman

R. Lawrence Snideman, II
President

cc: Pete McCloskey, Jr.
205 Cannon Bldg.
Washington, D.C. 20515

RCA|Government Systems Division|Marketing
1901 North Moore Street|Arlington, VA 22209|Telephone (703) 558-4627

RCA

D A Wilkinson
Manager, Federal
Agencies Marketing

March 4, 1983

Dear Pat;

Attacned is the summary of our response to the Department of Commerce RFI on Commercialization of Remote Sensing, which you requested.

In addition to this summary our response estimated that capitol costs for polar (NOAA) and sychronous (GOES) spacecraft for the decade 1989-99 in 1985 dollars would be almost $1.2B. This includes 10 NOAA and 10 GOES spacecraft & launches.

These figures do not include lessor costs of overhead, profit and interest on capitol. Such costs would vary widely depending upon contract conditions & the bank rates.

We believe the total of all these costs would exceed the cost for NOAA to continue to buy and operate these satellite systems.

If you need further information, please call me, 558-4627.

Sincerely,

Dave Wilkinson

DAW:cmh

RCA Position On

Private Sector Involvement in Civil Operational Remote Sensing from Space

Introduction

The major objective in the effort to commercialize the LANDSAT and Metsat (GOES, TIROS) programs is to reduce the cost to the government to operate these programs while maintaining the services provided. Having a private organization operate and maintain the current system does not necessarily achieve this objective. Any such organization would incur costs (such as taxes, insurance, and the cost of capital) to which NOAA is not subject. In addition, a private organization would make a profit based on a reasonable return on investment. These profits and extra costs would be passed on to NOAA resulting in a greater overall expense to the Government. Improved operating efficiencies and additional services could modify the situation.

Summary

LANDSAT: Private ownership of the total LANDSAT system including data seems premature because of the large commitment required by the U.S. Government to procure data to assure profitability. Rather, an interim lease agreement, for industry to operate the system and develop markets, may be the only practical approach.

METSATS: Private ownership of Metsat data is not viable because it implies ownership (control) of the NWS data base in order to develop marketable products for sale to other than government agencies. Such ownership is not in the public interest because of the value of weather data to public safety and welfare and the quid-pro-quo of weather and warning data dissemination. However, RCA believes that portions of the Metsat system can be leased as shown below.

- GOES lease service could be a cost reduction to the government if the service included the data distribution function for the National Weather Service. The real savings would be in the reduction of long line communications cost presently being funded by the National Weather Service.
- TIROS lease service does not appear per se to yield a savings for the government. Cost reduction could be achieved through the technology upgrade of the ground system; however, this savings will not offset the additional cost of lease.

GENERAL: It should be noted that all the savings identified herein, mission change and technology upgrade of ground system, are achievable by the government with or without leasing through private industry.

October 1982

SPACE
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October 22, 1982

Dr. John H. McElroy
Assistant Administrator for Satellites
National Earth Satellite Service
National Oceanic and Atmospheric Administration
Department of Commerce
Washington, D.C. 20233

Re: Civil Remote Sensing Satellites;
Request for Information

Dear Dr. McElroy:

On behalf of Space Services Incorporated of America ("Space Services") this letter is submitted in response to the Secretary of Commerce's request for the views of private industry with regard to the transfer to the private sector of the nation's civil remote sensing satellites. Commerce Business Daily, September 10, 1982; 47 Fed. Reg. 41152 (September 17, 1982).

I. SPACE SERVICES INCORPORATED OF AMERICA

Space Services is a privately held Texas corporation which intends to engage in a variety of commercial entrepreneurial outer space ventures. The initial objective of its activities is to develop a low cost, low earth orbit launch vehicle. On September 9, 1982, Space Services successfully launched into outer space the Conestoga I rocket, a prototype of the upper stages for the production version of the Conestoga rocket.

II. PROPOSED PRIVATE CIVIL REMOTE SENSING SATELLITES

Space Services is planning to launch private civil remote sensing satellites on its production version of the Conestoga rocket as early as 1984. Some of the remote sensing satellite projects being contemplated will complement existing Landsat capabilities; other projects would overlap existing Landsat capabilities. Once plans for these projects are finalized, Space Services will be making applications to the appropriate regulatory bodies for permission to launch such satellites and those applications can be expected to describe fully the activities contemplated by Space Services. As a consequence of this company's efforts to launch private civil remote sensing satellites, Space Services is aware of several companies which also are planning new civil remote sensing satellites and new data processing capabilities.

In summary, any decision to commercialize the government's civil remote sensing satellites must consider the impact of such action on a small, but growing private sector which intends to provide commercial remote sensing services, in some cases in competition with the Landsat system. Space Services has no intention of offering to purchase or operate the Landsat system, but, of course, the government's proposal to commercialize Landsat will directly affect Space Services' ongoing business plans.

III. FREE MARKET PHILOSOPHY

A fundamental principle of government policy is that the government should not compete with its citizens. See OMB Circular A-76. Space Services agrees with the Administration's decision to terminate the government's commitment to land sensing satellite data continuity through the 1980's on the grounds that:

> It is the Administration's judgment that the present NASA investment in Landsat is sufficient to permit evaluation of operational uses of Landsat data, and, if these uses are cost effective, to attract a private sector owner/operator.

Space Services has evaluated the operational uses of remote sensing data and has concluded that private ventures can replace the government's Landsat program and make a profit.

A corollary to the theory that government should not compete with its own citizens is that government should not create unfair competition among its own citizens. Any new private sector owner/operator of the Landsat system should be given an equal opportunity to compete in the marketplace, but should not be given an undue, perhaps even monopolistic, advantage over those companies such as Space Services which have plans to commercialize civil remote sensing satellites entirely through their own efforts and finances.

On July 4, 1982, President Reagan in his statement of space policy addressed the role of the private sector as follows:

> The United States Government will provide a climate conducive to expanded private sector investment and involvement in space activities.

Expanded private sector investment and involvement can result from both commercialization of government programs and independent private ventures. Space Services submits that commercialization of government programs must be accomplished in a way that does not inhibit investment in independent private ventures.

Space Services submits that the private sector is capable of operating civil remote sensing satellites subject to appropriate regulation relating to national security. Limits on prices to be charged, division of markets to be served, subsidies to private operators of the Landsat system, and guaranteed government purchases of Landsat services would hamper private market operations. While Space Services submits that some regulation is appropriate, economic regulation is unnecessary and potentially harmful.

IV. RELATION OF CIVIL REMOTE SENSING SATELLITES TO ENVIRONMENTAL (WEATHER) SATELLITES

Commercialization of civil remote sensing satellites should be considered separately from commercialization of environmental (weather) satellites. Including environmental (weather) satellites will raise important, unfortunate and unnecessary questions of cross-subsidies and monopoly power.

Space Services agrees with the Administration's present thinking that environmental (weather) satellites should not be commercialized now. Issues of public health and safety, national security, and international relations dictate continued government command and control.

V. USE OF GOVERNMENT FACILITIES

Space Services supports the concept of allowing the private sector to use government facilities and equipment already in place. Of course, the question of the level of compensation to be paid for such use is difficult. In view of the novelty of the issue and the need to balance competing interests, i.e., desire to avoid subsidy or unfair competitive advantage and the need to assist the private sector's entry into commercial space activities, perhaps each question regarding the level of compensation should be decided in light of the facts of each case.

VI. PLURALISTIC APPROACH NOT MONOPOLISTIC

To encourage a healthy, competitive private space industry the government should commercialize civil remote sensing satellites in a way that will maximize the number and diversity of Landsat owners/operators. Space Services submits that turning over the entire Landsat system to a single owner/operator would confer virtual monopoly power on the recipient. Separate entities should be considered as owners/operators for the following broad areas:

1. satellite design, manufacture and launch,
2. spacecraft tracking, and
3. data acquisition, and data processing and distribution.

In general as expressed in antitrust laws, this country abhors monopoly power which leads to inefficiencies, abuses and concentration of economic power. The government should make every effort to encourage a pluralistic approach instead of creating a vertically integrated monopoly of the entire Landsat system, which is comprised of assets totaling $1.6 billion.

As part of any pluralistic approach to commercialization of Landsat assets, provision should be made for access to Landsat facilities on a reasonably priced, non-exclusive basis. For example, spacecraft tracking and data acquisition services for Landsat satellites might be most efficiently used if available for independent private civil remote sensing satellites as well. Granting exclusive rights to owners/opeators of Landsat facilities would give them a substantial time and cost advantage over independent private ventures such as those contemplated by Space Services.

VI. REGULATION

Space Services recognizes that the Government will authorize and supervise private remote sensing activities in accord with the Outer Space Treaty of 1967 and national security interests. Given the fact that Space Services intends to launch private remote sensing satellites as early as 1984, designing an appropriate regulatory regime should be completed quickly. Space Services submits that such regulation should include the following characteristics:

1. A lead regulatory agency, probably either the Department of Commerce or the Department of State;
2. Clear, stable standards (satellites are designed and manufactured years before they are launched and used);
3. Expeditious processing of applications; and
4. Recognition that the country receives significant advantages from being the leader in civil remote sensing technology.

VIII. FOREIGN COMPETITION AND ITS EFFECTS

In connection with the two issues posed in this Request for Information as well as the many other issues that the Government will face in the coming years as the U. S. private sector and its foreign competitors proceed with the commercialization of outer space, the Government cannot and must not lose sight of the fact that if it does not provide the proper environment for our private sector to take the lead in space, foreign countries and entities will take the lead.

If the U. S. private sector is turned loose to exploit the opportunities that are now and will in the future become available, you can be sure that leadership in space will remain with the United States of America. However, unrealistic and burdensome regulations or inconsistent governmental statements and policies may retard the development of this new U. S. industry with the result that other countries will seize the opportunity, while the United States and our economy will lose the jobs, profits, technology and national prestige that are now within reach.

VIII. CONCLUSION

Space Services generally favors rapid commercialization of government space activities including Landsat assets. The method of transfer to private owners/operators should not discourage independent private ventures such as those contemplated by Space Services and its future customers.

Respectfully submitted,

Charles M. Chafer JRM

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Terra-Mar

Civil Operational Remote Sensing From Space

Conceptual and Marketing Overview
of the
Pertinent Issues Affecting the Commercialization
of Satellite Remote Sensing

October 22, 1982

Terra-Mar Document TMA 10-011-82

Terra-Mar is actively involved in developing an earth resources data service; however, this plan does not specifically involve the transfer of Government Landsat assets to the private sector. Therefore, this document does not outline Terra-Mar's strategy nor does it reveal confidential market research information gathered on a consulting basis over the last six years. This document does express the opinions of Donn C. Walklet, President of Terra-Mar, based on the evaluation of that market research. The material in this paper is meant for distribution to the appropriate Department of Commerce committees for their use in analyzing the civil remote sensing program. Otherwise, this document should not be copied or released without the written permission of Donn C. Walklet.

INTRODUCTION

Terra-Mar is a technology and management consulting company that has developed a significant depth of understanding of the potential markets for remote sensing data. Based on research conducted for numerous private sector clients over the last six years, Terra-Mar is proposing its own initiative for establishing an earth resources data base service.

Remote sensing can be a viable commercial technology. At this point, Landsat will be as much a hindrance to commercialization as a benefit -- unless the appropriate government groups take prudent steps toward smoothing a gradual transition toward private operation of remote sensing facilities. To a great extent, the marketplace should determine the best mechanism for making this transition possible, and the Government should facilitate an orderly transfer of technology.

The following paper is a discussion of the relevant issues from the perspective of an organization well versed in the potential of remote sensing technology as well as knowledgeable about the reality of its political and social impacts.

I. The Marketplace

The Government, through the NASA Landsat program, has significantly contributed to the future economic potential of satellite remote sensing. In spite of this contribution, however, an unfortunate lack of understanding has developed concerning the context in which remote sensing fits into a commercial environment. In NASA's sphere of operation, remote sensing is primarily an aerospace technology. In the commercial world, remote sensing is a computer and information technology and thus should be marketed accordingly.

No government agency has ever conducted marketing research to define the true potential of an information system based on real-time data acquisition from a network of low earth orbiting satellites. To a great extent, knowledgeable private sector groups understand that the gross potential revenues derived from all components of an earth resources data industry can be numbered not in the millions, but in the billions of dollars annually. Market potential is the key issue in making any economic decision about the future disposition of Landsat and its follow-on projects. Otherwise, it will be impossible to fairly assign values to current government assets or to determine a potential stream of earnings upon which to value the proposals from the private sector for ownership, control, and operation of the land remote sensing system.

Terra-Mar recognizes that future revenue from appropriate satellite sensors is directly tied to growth associated with the next generation of computer services. In this context, digital satellite imagery will be a valuable source of input into earth resources information services. Within the private sector, the infrastructure for this service capability is now in the development stage. Highly refined applications software which will convert imagery into information is on the threshold of greatly expanding the current limited user base. Furthermore, computer networks and distributed processing will provide convenient access to new markets from specialized earth resources data bases. This is a factual not a speculative scenario based on generally accepted trends which are fundamental to all computer service companies.

Terra-Mar's market projections derived from analyzing these technological trends provide the basis for pursuing commercial satellite remote sensing services. These projections assume an aggressive marketing environment -- unregulated and very competitive. In fact, the consumer is best served in such an environment. Consumers will not just be oil companies or the Government but all individuals seeking information about the surface of the earth. Under such commercial circumstances, concerns over "open skies" will be overcome by market growth, stimulated by new applications software and modes of delivery, and driven by the opportunities to expand distribution to all levels of society.

II. Landsat 4 -- Opportunities and Constraints

The addition of the Thematic Mapper (TM) to Landsat 4 has provided new modes for expanding the usefulness of remote sensing in the earth resource analyst's decision process. In this sense, TM represents a very significant contribution to commercial remote sensing because it provides additional opportunities for exploiting the electromagnetic spectrum in areas that are of economic interest to the resource community. Improvements in Landsat 4's data processing and communications system will also contribute to the timeliness and reliability of data delivery.

On the other hand, Landsat 4 is encumbered with technical and political problems which make its transfer to the private sector somewhat complex. The original value of the satellite and data processing assets is significant; however, on the open market, that level of technology is considered obsolete. Given the computer technology which is available today and which will make another substantial leap by 1984, Landsat 4-type equipment, primarily oriented for R & D applications, could be considered in financial circles to be a commercial liability. There is also a negative stigma associated with "Landsat" as a commercial concept. The entire process of "analysis" has politicized Landsat to the extent that the financial community views Landsat with a certain skepticism. In a commercial environment, Landsat is competing with other promising projects for capital, and there is a perception of risk associated with Landsat -- it is expensive, it is political, and the commercial opportunities are yet to be fully demonstrated.

However, there are some organizations which would exploit such a "hot potato", knowing that at a certain price, the problems of Landsat become bearable. The commercial operator of Landsat will maintain a distinct advantage by developing the satellite data business to his benefit and to the detriment of any future competition. Understanding the potential of this business is in the billions of dollars, one potential operator is seemingly willing to make sacrifices in order to establish a dominant position. If the selling price of Landsat is the discounted or depreciated value of its assets, this operator will be paying a small price in exchange for assuming that dominant position.

Landsat 4 should be utilized as a tool to stimulate the development of a private earth resources data industry. At this point, it would be very dificult to designate one company to assume the operation of Landsat with the subsequent responsibility for developing the market. Terra-Mar research indicates that such a company with the appropriate operational and marketing skills does not exist. However, within the next five years, new companies or a consortium of companies will develop that will have the skills to assume these responsibilities in the long term. In the meantime, improvements in data processing and data distribution will stimulate the groundswell of value-added activity which is already occurring, thereby increasing revenues from Landsat data sales in the future as new applications become entrenched in the marketplace. Strength among private sector operators will eventually permit backward integration into data receipt and archiving as well as the development and operation of orbiting sensors. In this mode, healthy competition will encourage the creation of new applications software as well as encourage the companies with the best capabilities to assume a leadership role in developing a fully integrated earth resources information system.

III. The Issue of Environmental Satellites

Without considering the political and social implications, grouping the environmental/weather satellites with land remote sensing satellites makes significant operational and economic sense. Both satellite systems produce complementary data sets which can produce valuable information products when combined in the appropriate marketing environment. That such a merging of sensing capabilities will eventually occur is inevitable in a commercial situation.

In the near term, however, the problems of untangling the political implications of combining the two data systems outweighs the potential commercial benefits. The environmental satellites are tied to treaty obligations, military weather observation programs, and health and safety issues which make their transfer to the private sector a very sensitive issue. This situation can be dealt with in time, but the uncertainties associated with their disposition could seriously inhibit the commercial development of land remote sensing systems within the private sector. The difficulty of establishing the commercial viability of satellite remote sensing is sufficiently serious without adding to the perceived risk by associating remote sensing with another politically hot issue such as the environmental satellites.

As stated previously, there is market research which indicates that remote sensing can establish commercial viability for itself within the decade without the association with environmental satellite revenues. Although the pairing of these systems would permit certain operational efficiencies, the economic benefits derived by utilizing environmental satellite profits to bolster the losses of the land remote sensing system in the near term would be politically unpalatable. Furthermore, such an indirect subsidy would destroy the incentives to develop land remote sensing to its full potential, and thus a condition of profitability.

IV. Satellite Remote Sensing Legislation

Transfer of Government remote sensing facilities to a private company, the creation of a Government corporation, or the establishment of a for-profit private corporation would require the writing of enabling legislation. If one of these three alternatives was in the best interests of the Federal Government, and the country, and would be the best means of launching a new industry, the writing of legislation would definitely be justified.

On the other hand, if past experience is a reliable indicator, any of these alternatives would be less desirable than not writing legislation, and allowing the market to determine those commercial entities with methods and strategies best suited to assume operational control of an integrated remote sensing system. Through the development cycle of Landsat, the Government has treated remote sensing like another aerospace technology rather than an information technology. Furthermore, remote sensing cannot be commercialized in the "Comsat" mode where a designated government entity was created simply to supply an additional and more efficient means of data transmission in a rapidly expanding market. Communication satellites may have represented a technical, organizational, and legal challenge but certainly not a marketing problem.

Remote sensing is a substantially different marketing situation. The current users of satellite data are relatively sophisticated technicians and analysts who directly interact with mainframe computers as part of their job. The mass market for earth resources information, of which satellite data will be an important component, will be individuals from many occupations with repetitive needs for resource information on a local to a global scale. These individuals do not want to write computer programs. They do not care where the information comes from as long as it is accurate and timely. They are not particularly interested in the wonders of remote sensing. They are people with questions and problems and will buy services which directly address their information needs.

The Government and its private contractors created Landsat and the concept of satellite remote sensing but have never adequately addressed the complex marketing issues of serving a segmented, multifaceted user community. This history does not portend well for the success and profitability of a Government spawned venture without a marketing orientation. Furthermore, the most expeditious and aggressive development of this market will require management to exercise significant flexibility and creativity in addressing new applications and opportunities, a quality more characteristic of small, entreprenurial organizations than large, Government sponsored enterprises.

It has been suggested that legislation would be required to ensure open access to satellite imagery generated by a privately owned sensing system. To suggest that this legislation is necessary is to ignore the fact that commercial remote sensing is totally consistent with the objectives of the "open skies" policy. The capital intensive nature of a future remote sensing/earth resources information industry will dictate that no single market segment will dominate the operational priorities of its management. The key to profitability lies in developing computer and communication tools combined with creative marketing strategy which will lead to many new applications, penetrate new markets, and geometrically expand the current user base. Reaching the mass market requires open access to data. Although the raw data producers should have proprietary or copyright protection for their data, it will be in their best interests to seek wide and nondiscriminatory distribution of their product. Among developing countries there is a sensitivity to the potential private operation of satellite sensors, their citizens fearing exploitation by those with access to nondisclosed information about their internal resources. A free market and healthy, open competition will eliminate that possiblity and provide the developing countries with access to resource evaluation tools previously unavailable. In this sense, successful commercialization of remote sensing and associated earth resources information technologies will represent a great "equalizer" among the industrialized and developing countries.

The point that should be made is that legislating access to remote sensing data may be premature, unnecessary, and detrimental to free market development of the technology. Legislating answers to problems that do not exist will not benefit the commercialization of remote sensing, whereas Congress can expeditiously address the issues of private "hoarding" of satellite data if a future situation requires a legislative fix.

V. Transition and Technology

Terra-Mar's market projections are partially based on the premise that major evolutions in electronics technology will pave the way for the operational requirements for a functional and cost-effective earth resources information industry. No matter what decisions are made about remote sensing, we can anticipate surmounting at least three major electronics hurdles in this decade. These will include major achievements in microcircuitry, data storage and communications, and in man-machine interface techniques. In turn, the commercial enterprises which will succeed and lead in developing an earth resources information industry will be those which mobilize these technology achievements in the best, most responsive marketing infrastructure.

The Multispectral Scanner and the Thematic Mapper have represented developmental tools in an R & D environment. However, future sensors will take advantage of improved electronics to upgrade the quality and reliability of sensor performance while reducing the upfront cost of fabrication. This capability will be further enhanced by improved modes of deployment including shuttle and space platform pallets. In such an operating mode, additional opportunities are available to reduce fabrication and operating costs associated with modular sensor architecture permitting rapid repair and component replacement at periodic maintenance cycles while in orbit. Thus, the market potential for satellite data services will be leveraged by the decreasing cost of data acquisition at the same time that the fixed operating expenses of maintaining sensors in orbit will be spread across a rapidly increasing user base.

Sensor specifications will be determined on the basis of ongoing interaction with the user community, interpreting their information needs into engineering and operating parameters for imaging systems and data processing facilities. For the immediate future, NASA will continue to play a critical role in developing and testing sensor technology at a time when a young industry will be unable to afford this sophisticated function. As in other NASA research programs in conjunction with the aircraft and airline industry, this investment in sensor technology will pay long term dividends to the Government in the form of tax dollars as an embryonic earth resources information industry develops into a multi-billion dollar business by 1990.

VI. Products and Pricing

NASA and NOAA should endeavor to expedite the access, processing and delivery of the Thematic Mapper data as well as the output from the Multispectral Scanner. Reliable and sustained production of data from these sensors will allow the value-added services market to evolve expeditiously. Delays, for whatever reason, will postpone the opportunities to penetrate new markets and thus to start the process which will eventually permit backward integration into orbiting sensor development and operation.

Product pricing should be based on the discounted life-cycle costs and revenues of Landsat 4 and Landsat D' rather than attempting to recover year to year operating costs. By maintaining low data prices in the near term, application and market development will progress at a much faster rate generating operating revenues for Landsat 4 in 1986 which far exceed annual expenses. Therefore, a near term product pricing strategy which stresses the benefits of reaching new data customers will ultimately generate more revenue for the Government while stimulating commercialization and the growth of a prospering new industry. Pricing strategy is a fundamental component of effective marketing, and the Government must assume that Landsat data products are not an exception to this rule.

VII. Competition Issues

There are several countries which have already announced their intentions to develop a commercial satellite remote sensing capability during this decade. Other countries are waiting on the sidelines, observing the United States Government and its private sector, and looking for any signs of weakness and lack of resolve in dealing with this earth resources satellite issue. The objectives of these countries and their governments should not be misunderstood. Recognizing the commercial opportunities which satellite remote sensing will generate and having obtained technical and marketing information from public documents in the United States and by hiring the best of U.S. consultants, these countries will proceed to establish earth resources information services, based upon the investment of United States taxpayers, and sell the United States products and services which it is unwilling to provide for itself. Some individuals, inside and outside of government, believe that this is not a critical issue, but without the commercial incentives, United States industry will not continue to maintain its technology edge, the country will suffer an additional increment of balance of payments losses, and the Government will fail to reap the tax benefits that a healthy new industry would derive. Strategically, the United States, which is already dependent on outside suppliers for the majority of its most important raw materials, will be dependent on outside sources for perhaps the most important commodity, information.

Concerning the issue of "leaks" of our technology to foreign countries, it should be apparent that whether friend or foe, whoever wants our technology will eventually find a means to obtain it. In this situation, the best defense is a good offense. We must continue to aggressively develop our technology base in areas which will generate profits as well as benefits for humanity. Thus, the U.S. challenge is to maintain and to stimulate the incentive system of its society which is the basis for its high technology leadership.

On the other hand, international competition is desirable in this earth resources information arena. Remote sensing is a global technology, and a cooperative effort in developing and operating complementary satellite systems among several different national entities will allow for a more healthy distribution of risks and rewards on an international scale, not to mention the potential intangible benefits of a worldwide sponsored program to monitor resources as well as weather information. Furthermore, a cooperative effort will minimize the opportunities for and, perhaps more significantly, the perception of data manipulation among the leaders of developing countries.

However, within a cooperative international system of earth observation, the United States should attempt to maintain a leadership role. The United States developed remote sensing technology and endorsed the "open skies" policy as a fundamental part of its operation. Leadership will leverage profits, but it will also ensure data availability on a basis unaffected by political whim.

VIII. Overview

Satellite semote sensing is a spinoff of NASA's aerospace accomplishments and the commitment of a few resource scientists who had the vision to recognize its potential. Remote sensing has made incredible strides in just ten years at Government expense, and now is not the time to abandon its development at the point when commercialization will allow it to bear abundant fruit. The economy is limiting the opportunities which the Government can undertake. In such a situation, the Government must look to the knowledge, experience, and initiative of its more creative citizens. The answer to the problem may not be so difficult. The ingenuity which has taken the "Apple" computer from an idea in a garage to a $5 billion industry in six years can address the commercial opportunities of remote sensing -- a technology which may provide access to unlimited knowledge of our resources and environment.

October 20, 1982

A Plan for Commercialization of the U.S. Civil Remote Sensing System

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This document is being submitted in response to the September, 1982 request for private sector views of policies concerning commercialization of the nation's civil remote sensing system. Since the issuance of PD/NSC-54 in November, 1979, the University of Massachusetts Remote Sensing Center has been coordinating the development of a plan for commercialization of the civil operational remote sensing system. In this document we briefly summarize our views and discuss a plan for UMassachusetts-facilitated implementation.

It is our opinion that direct transfer of the LANDSAT or weather satellite systems in their present forms to the private sector is not the best solution. The systems were not designed from the outset to operate commercially. The prospect for profitable return from these systems in their present form seems minimal without significant federal incentives, such as subsidies to reduce the acquisition cost (e.g., government furnished equipment), and/or large data purchase guarantees. Such transfers, particularly of the weather satellite systems, would be further complicated by the requirements for priority service to DOD and related national security issues, as well as the need to preserve current international relationships.

We propose an alternative solution. The University of Massachusetts plan calls for a modification of the current LANDSAT and weather satellite systems that would permit gradual and stepwise commercialization. Both

LANDSAT and the weather systems would be involved in the commercialization process, but the weather systems might be only partially commercialized.

The plan calls for a nondisruptive decentralization of the systems, followed by gradual commercialization of the components. The plan has been designed to create real market incentives for commercialization that would obviate the need for federal incentives such as subsidies or data purchase guarantees. The approach would promote competitive rather than monopolistic enterprise, and it may provide significant increases in data accessibility, variety, continuity, and reliability. The transition would proceed with minimum disruption of system operations and services. National security requirements and international relationships would be preserved.

The following steps would be followed:

1) Addition of User Interface Facilities. It is proposed to first develop a network of *User Interface Facilities*. These facilities would be gradually added to the current systems, accompanied by shifts in functional responsibilities. The facilities would be established to handle all user requests for data, including acquisition, processing, and distribution. They would also provide user training and project consulting services. The facilities would be designed from the outset to operate profitably. To achieve this they would cater to user groups with common needs. By focusing on specific target clientele, they would be subject to an inherently manageable and definable demand. They would also be able to provide tailored services that would allow them to increase the demand. The result would be a cost-efficiency that would permit profitable operation.

During the first stage of the commercialization plan the current system would not be modified except for the addition of the User Service Facilities. Users would still have the option of ordering data directly from EDIS and EROS, but they would now be presented at the outset with the additional option of acquiring services from the User Interface Facilities.

The proposed design of the User Interface Facility focuses on achieving high data throughput and on actively developing a large user base. The means of achieving high data throughput is an emphasis on *direct downlink data acquisition.* Requests for data from environmental satellites (GOES, NOAA), LANDSAT, foreign, and private sensors would be satisfied by direct acquisition, rather than by retrieval from archives such as EROS and EDIS, whenever possible. National archives would be utilized only when necessary (temporal comparisons, historical events, etc.). This would circumvent the bottlenecking limitations imposed by the archival process on data throughput. It would also reduce the loss of revenues that result from multiple user sharing of data tapes. We have designed an Automatic Data Acquisition and Processing System (ADAPS) that could be developed at low cost. It would permit direct acquisition from multiple sensors and provide level 1a to 1b processing automatically. It would provide flexible and widespread spatial coverage. The level 1b data provided by ADAPS would be either directly shipped to the user, or further processed by the Data Analysis Service as required. By circumventing an archival step, the throughput from ADAPS could be substantial.

Although the plan emphasizes acquisition via ADAPS, the need for archival data will still be appreciable. In order to limit bottlenecking created by placing all the demand on the central archives (e.g., EROS and EDIS), the design calls for the establishment of a limited local archive of frequently used data. The User Service Facility may maintain a small rotating archive of the latest (possibly up to a month) GOES and AVHRR data, as well as a limited archive of frequently-used land imagery. The rest of the archived data would be ordered on behalf of the user from the national data archives. All requests for data, whether supplied by ADAPS, the rotating archive, or from national archives, would be handled by the same *Data Retrieval Service*.

The Data Retrieval Service would also be responsible for distributing data from ADAPS, the local archive, and the national archives. This would be done by conventional mail, express delivery, or courier service.

Data processing would be done by the *Data Analysis Service* at the User Service Facility. This would include standard or specialized image processing, geographical information system products, digitizing/colorwriting, and hard-copy/graphics productions. Project consulting services would also be provided.

The University of Massachusetts plan calls for a deliberate broadening of the user base. We have developed several technical innovations to achieve this goal. Details will be provided upon request. In short, they have enabled the establishment of a personal computer network which could handle routine image transmissions of high interest (analogous to WEFAX, except digital and in color). This has required a technological breakthrough in data formatting that permits rapid transmission of digital imagery over unconditioned telephone lines. The network would also supply computer-mediated user training for the non-technical user, a breakthrough which we have also recently accomplished. The broadened accessibility to data provided by the network transmissions and personal user training coupled with vigorous marketing should provide a significant fee base. As the network users mature, the demand for conventional data tapes and hardcopy should grow.

This design for the User Service Facility should permit the achievement of profitable operation within a relatively short period. The Facilities should be developed and operated as a profit center from the outset. Initially, a network of Regional Facilities would be appropriate. As the market increases additional facilities might be supportable to serve common-needs industrial clients (e.g., energy industry, agribusiness, ets.) or to cater to specific federal clientele.

The first phase of the plan involves the simple creation of User Services Facilities. The existing federal system would be virtually unaffected, except for an increased demand for data. The User Service Facilities would pay appropriate access fees (e.g., LANDSAT) to the federal government for ADAPS, and pay the appropriate data charges to the federal archives. Special high-volume rates may be arranged, but no subsidies should be required.

2) Private Sensor Systems. The second step of the commercialization plan is to develop low cost privately-owned sensors to supplement the existing sensors. A significant fraction of our two-year effort has been involved in the development of innovative approaches to sensor, space craft, and ground support equipment designs that would permit profitable operation of earth orbiting sensors. Three private firms have expressed interest in such

designs and development efforts are in progress.

The currently envisioned sensors would provide LANDSAT-like data, as well as other data types that are designed to attract broad market interest. The value of the LANDSAT data is recognized, and the sensors are being designed to complement LANDSAT, not duplicate it. With the broadened market created by the User Interface Facility network, the demand for LANDSAT data and weather satellite data would remain high and might even increase, despite the introduction of private sensors. The federal system would maintain a strong user base during the initial stages of this phase.

As the market develops, it would be expected that subsequent generations of sensors would begin to satisfy the bulk of the market. This would hopefully be achieved before the LANDSAT satellites cease operation.

3) Federal System Adjustment. The third part of the University of Massachusetts plan calls for responsive federal adjustments to the evolving commercialization process.

Some adjustments would occur early, at the national archives (EROS and EDIS). It would be expected that the User Interface Facility network would increase the demand for level 1b data from the archives, while not producing increases in processing demand. Standard or special product generation would be done by the Data Analysis Service. The result would be a gradual phase-out of processing by the archives and a shift of that function to the User Interface Facilities. The archives would evolve toward mre efficient cataloguing, storage, and retrieval procedures, and develop efficient interfaces to the User Interface Facilities. This would increase the data throughput and fee base of the archives, as well as the User Interface

Facilities.

It is anticipated that the need for such archives will eventually vanish as improvements in digital storage media (e.g., video disk) continue. The archives should probably remain under federal control until their need expires. The transfer of functions to the User Interface Facilities could be gradual and beneficial to both in the interim period.

Another adjustment that should occur responsively is a shift of data acquisition responsibility to the User Interface Facilities. As ADAPS downlinks develop, full spatial coverage would result. The coverage would become naturally redundant, and the need for federal acquisition would diminish for those areas. The result should be a gradual shift of data acquisition function to the User Interface Facilities. If adequate data can be supplied to federal and private users by the User Interface Facilities, those facilities should become the primary data sources.

For weather data, the User Interface Facilities may not achieve sufficient dependability status to satisfy national security requirements (e.g., priority service to DOD), in which case a federally operated data acquisition capability may need to be retained. The commercial sector should, however, be the supplier of weather data products to the federal government during all situations where the demand can be adequately handled.

For LANDSAT a complete transfer of data acquisition function to the User Interface Facilities should occur responsively. Those services that can be adequately provided by the User Interface Facilities should be transferred to those facilities.

4) Full Commercialization. The end product of the above three steps is full commercialization of the U.S. civil remote sensing system. The User Interface Facilities would fill the data acquisition, processing, and distribution needs of the users. Private sensors would gradually replace federal sensors. The federal program would gradually phase down, except perhaps for segments of the weather satellite system. The result could be achieved without federal subsidy, and the transition would be non-disruptive. Federal involvement would disappear by normal attrition.

Implementation. It is our opinion that the commercialization process outlined above could proceed without government funding or subsidy at any point. Development of User Interface Facilities and sensors could be funded entirely by the private sector. No government facilities or equipment would be needed.

Development of a prototype User Interface Facility and a private sensor could begin immediately. The 24-month program at the University has resulted in low-cost designs for the User Interface Facility and for a commercial sensor. Private funding for development of both at the University is currently being coordinated. First-quarter 1983 starts are anticipated.

Current plans call for the prototype User Interface Facility to be operated and maintained by the University. Full U.S. coverage is planned. Specific data to be acquired, fee structures, and data costs have not been established. Foreign export of data is not anticipated.

Sensors that would be designed and/or developed by the University would not under current plans be owned by the University. Area of coverage, spatial resolution, sensor frequency bands, interval between repeat coverages, etc. would be determined by the contracting party.

The time scales for development of follow-on User Interface Facilities and sensors are difficult to assess. The development programs at the University will address possible further reductions in the costs of systems and possible expansion of the user base into non-traditional markets. This should facilitate expansion. Initial estimates suggest that significant progress toward full commercialization could be realized within 6-10 years.

Possible changes in federal regulations that may facilitate commercialization have not been addressed. No new legislation would be required to our knowledge.

November 17, 1982

REPORT OF THE WORKING GROUP ON COMMERCIALIZATION
LAND REMOTE SENSING SATELLITE ADVISORY COMMITTEE

SUBJECT: Evaluation of Responses to NOAA Request for Information on Civil Remote Sensing

ORGANIZATION OF THE WORKING GROUP ON COMMERCIALIZATION

The Working Group on Commercialization was organized at the request of the Chairman of the Land Remote Sensing Satellite Advisory Committee. The purpose of the Working Group was to organize materials for the main committee and identify issues and actions for the main committee to consider.

SUMMARY OF ACTIVITIES

The Working Group met at the Department of Commerce, Room 5803 from November 1-4, 1982, and reviewed fourteen responses (Attachment 1) to the Commerce Business Daily, September 10, 1982, Request for Information (RFI). Additional budgetary information was provided by NASA and DOC.

The responses were highly variable, ranging from a postcard to a two volume proposal. The responses were analyzed using criteria developed directly from the Request for Information and its later published preamble (Attachment 2). The members of Working Group on Commercialization (WGC) evaluated the technical feasibility and degree to which responses addressed federal needs for land and weather satellite data.

After the responses were evaluated using the criteria in Attachment 1 they were grouped into four categories (Attachment 3):

1. Responses which did not specifically propose a framework for prompt commercialization.

2. Responses which did not recommend commercialization.
3. Responses which dealt with commercialization of only weather or only land satellites.
4. Responses which recommended immediate commercialization of both weather and land satellites.

After the responses were categorized and evaluated (Attachment 4), the Working Group considered fundamental concepts bearing on commercialization (Attachment 5) in the light of the various elements of a civil remote sensing system (Attachment 6). The following discussion represents our findings based on this analysis.

SUMMARY OF FINDINGS OF THE WORKING GROUP ON COMMERCIALIZATION

Members of the Working Group were in unanimous agreement that commercialization of activities within the Government which were not inherently governmental should enhance the development of the economic base of the country. Such commercialization should also lead to expanded tax revenues and introduction of better operational systems because the needs of the marketplace should drive the requirements for current technology. It was generally felt that commercialization should be accomplished in the environment of an open marketplace which encourages free enterprise and healthy competition on both a domestic and international scale.

The majority of the responses indicated that commercializiation should occur gradually beginning with the ground data handling segment of the land remote sensing system. All responses indicated that the market for land remote sensing data was not developed to a point where commercial viability could be demonstrated within the next ten years. Generally most respondents felt that designation of a sole operator, which would have exclusive and proprietary rights to the data from acquisition to delivery to users, under conditions of guaranteed subsidy and guaranteed tax incentives would severely limit the degree of natural market development. The Working Group also felt it was absolutely essential to get the Government out of those elements of land remote sensing which affect the market directly. Specifically those elements involve services to: 1) convert raw data into images in computer compatible tape and film product form; 2) enhance, process and analyze image data; and 3) distribute image data to non-government users.

International competition in civil remote sensing was regarded as healthy, however the Working Group felt that it was important to recognize that the most serious foreign competitors in the data market (France and Japan) write off the costs for operation of their space segments in the hope that the activities of their ground segments will lead to new information technologies that will rapidly enhance growth and development of their economies. For this reason it is doubtful that a United States commercial venture, which recovers the costs for operation of the space segment, will be able to compete on an international basis without Government support. The Working Group also recognized that foreign competitors also write off aggressive research and development efforts within their government as investments in their economic future. Serious concern was expressed by members of the Working Group that the responses only proposed very conservative, proven technologies for new systems to be utilized in the next decade.

Concern was expressed by members of the Working Group that the Government must aggressively support remote sensing research of a fundamental, high-risk and longer term nature, because such research in development of advance technology will not be done by industry. Industry will focus on applied, low-risk and short-term research to improve profitability using current, proven technology. A program board was suggested as a means for evaluation requirements for research within the Government with respect to the needs for advanced technologies.

The matter of commercialization of weather satellites was carefully analyzed in the light of the responses. The Working Group concluded that there was only a small commercial opportunity associated with weather satellites because the Government is the almost sole user of data produced by them. Therefore the weather satellite systems were judged to be inherently governmental. A large market for weather satellite data might be developed, but the National Weather Service would have to be commercialized before it can be tapped. Members of the Working Group also concluded that there would be a greater efficiency by managing both the land and weather satellite systems as an entity. Common satellite command and control, common data reception, and common raw data recording and archiving facilities could be utilized. Weather data could be used to target land data acquisition and to correct land data for atmopsheric effects. The issue of the degree of savings to the Government for combined operation of land and weather systems could not be quantified by the Working Group. We felt that the issue should be more appropriately improved products and services and therefore a more competitive system for the international marketplace.

On the basis of the responses, we concluded that major commercial opportunities exist in the value-added portion of civil land remote sensing. One of the reasons that market development has been inhibited is that the Government has extended its activities in those areas of data management that are non-governmental and the Government has managed the ground segment in an experimental rather than operational mode. Specifically the Government has developed the system to support the needs of scientific investigators rather than user applicators. Thematic Mapper data are vital for market development. The current lack of availability of Landsat-4 data is testimony to the problem. On the basis of the responses there appears to be industrial interest in receiving land satellite data directly, and distributing such data in near real time to users. Although there is a perceived need to have data archived in raw form and also to provide the Government with near real-time data, the Working Group felt the commercial sector should also be permitted to have direct access to the down-linked Government data stream. Access to this Government data stream should be permitted on a cost reimbursable basis. The Working Group concluded that value-added industries should be allowed to develop pre-processing services that would format raw data to images in film and computer compatible tape (CCT) form. Users having a need for raw, unprocessed data should be allowed to obtain copies of such data directly. Users having a processing and analysis capability could order film and CCT data directly from such value-added industries, or those lacking a level of sophistication in image processing could also request additional services (Attachment 6).

The Working Group also recognized that there would be an efficiency in management that would derive from operation of the space segment by a sole entity. Certainly a hand-off to the Department of Defense in times of emergency would be facilitated. However, the Working Group felt that it was not clear that a hand-off of the ownership and management of the space segment to an industrial entity would lead to increased profit opportunities for the aerospace industry. On the basis of the majority of the responses the Working Group concluded that if a sole entity is selected to operate the space segment its span of control over the data should only extend to the raw, unprocessed data. Secondly, the Working Group concluded that if Government facilities are utilized in any manner, or a Government subsidy is provided, such raw data should be placed into a National archive in the public domain. The sole entity operating the space segment should not be allowed to compete unfairly with the value-added industry in furnishing processed and analyzed data to users. At the same time there was a concern that the market must drive data acquisition technology, data acquisition plans, etc., if commercialization is to succeed. It was concluded that a review board should be formed to reconcile the differences between market requirements generated by users, the needs of the value-added industry and the needs for new efficient data collection technology.

Several responses indicated a desire to fly their own specialized sensors and have proprietary rights to the data provided by such sensors. Because there is not a market which could support such a possibility in the near term (the next 10 years) the Working Group felt the Government could stimulate commercial opportunities of this kind by providing launch services and/or access to satellite platforms in the near term. If public monies are used, then data so acquired could be placed into the public domain, but the Government should not be allowed to distribute such data, except for its own internal use.

Finally, with respect to a specific response proposing hand over of both the weather and land satellite systems, the Working Group concluded that natural (as opposed to subsidized) commercialization would be adversely affected if a sole entity was given proprietary rights to the data and had control over the data to include value-added services and data distribution to users. The Working Group concluded that if the operation of the weather and land satellites is handed off to a single industrial entity, that control over the data should only extend to raw, unprocessed data that is archived in a National facility.

ANALYSIS OF THE CURRENT SITUATION

The Administration has explicitly stated its intention to transfer its responsibility for land remote sensing to the private sector in the mid-1980's or sooner if possible. To this end the land remote sensing program is not funded beyond Landsat-D' scheduled to operate until 1988. With the lead time required for development of new satellites, a decision must be made in early 1983 to either request supplemental funding for continuation of some of the Government program or a viable corporate entity must be selected now to take over the entire program. Based on the responses no industrial concerns are willing to take over only the land satellite program without substantial subsidies and extensive Government involvement in the program for ten years. However, a great opportunity now exists to commercialize portions of the civil remote sensing program. Continuation of an all Government program was judged not to be the best method to develop commercial opportunities. Regardless of what decision is made, however, it is essential that the land remote sensing program continue without interruption.

To do nothing will be disastrous for our civil remote sensing program. Such an irresponsible do-nothing decision in 1983 will result in a break in data continuity, may foreclose effective commercialization, and may surrender our competitive edge to the foreign sector. The Land Remote Sensing Satellite

Advisory Committee has an opportunity to affect the decision process on this matter. The short history (Attachment 11) bears out the fact that OMB is committed to immediate transfer of all civil land remote sensing activities to industry to achieve immediate cost savings for the Government.

Congress has been supportive, but the land remote sensing program lost two major supporters in the recent elections, Senators Cannon (D) and Schmitt (R) and there will be major changes in Congressional staffs who have been working the Landsat issue on a daily basis. The realistic view on the Hill is that civil remote sensing is not a major issue for Congress.

ACTIONS FOR THE COMMITTEE TO CONSIDER

1. Recommend the Government aggressively support civil remote sensing research of a fundamental, high-risk and longer-term nature that will not be done by industry.
2. Recommend that the Government support the space segment and ground segment, up to and including only archiving of raw, unprocessed data, of the civil land remote sensing system until commercial viability in the international marketplace is assured.
3. To implement any decision to commercialize it is recommended that the Government request formal proposals from industry for operation of the space and ground segments, up to and including only archiving of raw, unprocessed data, of the land system by itself, or both the weather and land systems. Specific system characteristics shall be chosen to enhance utility to users and shall be specified by the Government.

4. To implement any decision to commercialize, it is recommended that the Government request proposals from industry to operate commercial sensors, at any time, on Government owned and furnished equipment that may be operated by industry for the Government.
5. Immediately request establishment of a Board of Directors for Civil Remote Sensing, appointed by, and reporting directly to, the President of the United States.

EXPLANATION OF RECOMMENDED ACTIONS

Action 1. Government research is critical to the development of commercial opportunities in remote sensing on an international scale. Funds for this research have been cut back and curtailed because the commercialization issue has not been resolved by the Government. Such research includes laboratory, field, aircraft, spacecraft, and satellite experiments to develop and test the utility of new instrumental techniques and concepts. The multispectral linear array research program, including the development and testing of advanced solid state imaging spectrometers on Shuttle, is key to future commercial success of the land program. Research in advanced radar antenna design and on board signal compression techniques is critical to the development of future commercial radar system. This action requires an immediate supplemental appropriation in the FY 83 budget and an FY 84 budget addition now to begin immediately the R&D for Landsat D'' and D''' to insure data continuity. The Board of Directors for Civil Remote Sensing, recommended in Action 5, should commission studies by the National Academy of Sciences and other scientific and engineering bodies as appropriate to determine the needed research thrust within the Government.

Recommendations by the Board should guide the appropriate level of funding and thrust for research within the Government.

Action 2. Government funding of the space and ground segment of the land remote sensing system will be required until 1995, and probably through the year 2000, if the United States expects to remain competitive in the international marketplace. This action requires an immediate supplemental appropriation for the FY83 budget and it requires an FY84 budget addition now. The Government should own the system, including a national facility for archiving of raw, unprocessed data. However, as suggested in Action 3, industry may operate the system under contract or leased. This will insure that launch services, satellite platforms, and sensors will be developed and flown throughout the coming decade while the market is being developed. The Government will also have to fund its own data processing facility (probably the EROS Data Center) to process raw, uncorrected data to image form (as Computer Compatible Tapes or film products). Such image data should be distributed only to Government agencies for their internal use. Private industry, state and local government, private citizens, and foreign governments would buy their data through commercial outlets — value-added suppliers (Attachment 6). State and local governments and scientific investigators which are funded by the Government for projects or research with satellite data should receive additional monies from the Government so they can purchase such data through commercial outlets.

Action 3. It may be more efficient and economically beneficial to the user if industry operates civil land remote sensing systems in an operational mode for the Government. The Government may remain the owner of such systems and should fund new technologies which will improve service and enhance development of the market. There may be additional economies and benefits to users if both the land and weather satellite systems are managed as a whole. If a sole industrial operator is selected by the Government to manage the land system, or a combined land and weather system, then this operator should not engage in unfair competition with the value-added industries or other industries in providing data to the Government or to private users. In this regard, the span of operational control by such a sole industrial contractor should not extend beyond the archiving of raw, unprocessed data.

Action 4. Government should stimulate commercial ventures in civil land remote sensing by encouraging industry to replace older technologies employed by the Government, or to employ new advanced technologies for which there is a perceived commercial market. If a commercial venture is possible, then the Government might provide the launch services and the spacecraft platform at no cost to the commercial operator in exchange for the data produced by the sensor. Data provided to the Government should be used for internal purposes only. The commercial operator should be allowed to have proprietary rights to the data stream and to sell such data to private users under copyright. The Government should also provide an environment where, if a commercial entity wishes to launch, operate and collect data from its own system, it should be permitted to do so and have exclusive, proprietary rights to the data. The Government's civil remote sensing program should not compete in any way with commercial ventures. The Board of Directors, suggested in Action 4, should establish mechanisms for evaluating industry commercial ventures, and should insure the Government promotes commercial opportunities.

Action 5. One of the most significant problems in remote sensing has been the lack of direction for the program. The Board of Directors should be composed of mostly nationally recognized business persons from the commercial sector and a few scientific experts. Great care should be taken to select business persons who do not have conflicts of interest with the value-added, remote sensing or aerospace industries. Also, great care should be taken to avoid persons from special interest or advocacy groups. The Board of Directors for Civil Remote Sensing should evaluate Government programs of research in civil remote sensing systems, industry proposals for commercial activities, etc. The main purpose of the Board will be to maximize commercial opportunities while insuring the public interest is served by civil remote sensing programs. Recommendations sent to the President by the Board should, if accepted, provide a framework for policy development and therefore would guide funding and management of civil remote sensing.

FINAL RECOMMENDATIONS

THE COMMITTEE BELIEVES, WITHOUT RESERVATION, THAT THE U.S. GOVERNMENT MUST COMMIT ITSELF IN THE BEST INTEREST OF THE NATION TO THE CONTINUITY OF A GOVERNMENTAL AND/OR PRIVATE SECTOR CIVIL LAND REMOTE SENSING SYSTEM. THIS CONVICTION STEMS NOT ONLY FROM THE ROLE REMOTE SENSING TECHNOLOGY WILL PLAY IN ENHANCING THE ECONOMIC BASE OF THE COUNTRY BUT ALSO FROM THE PERVASIVE INFLUENCE SUCH INFORMATION WILL HAVE ON IMPROVING THE FUTURE QUALITY OF LIFE ON EARTH.

THEREFORE, WE RECOMMEND THAT:

1) THE GOVERNMENT OF THE UNITED STATES WILL ATTEMPT TO NEGOTIATE AN ARRANGEMENT WITH PRIVATE INDUSTRY TO OWN AND/OR OPERATE UNDER CONTRACT SPECIFIED SPACE AND GROUND SEGMENTS, UP TO AND INCLUDING ONLY ARCHIVING OF RAW UNPROCESSED DATA, OF THE LAND SATELLITE SYSTEM BY ITSELF, OR BOTH THE METEOROLOGICAL AND LAND SATELLITE SYSTEMS.

2) THE GOVERNMENT OF THE UNITED STATES WILL MAKE A FIRM, LONG RANGE COMMITMENT TO CONTINUE TO PROVIDE OR CAUSE TO BE PROVIDED VIABLE R&D PROGRAMS ON BOTH THE LAND AND METEOROLOGICAL SATELLITE PROJECTS.

3) THE REQUIREMENT BE MADE THAT THE OPERATOR, WHETHER IT BE THE GOVERNMENT AND/OR THE PRIVATE SECTOR, SUBSCRIBE TO THE OPEN SKY POLICY - WHICH PRIMARILY MEANS THAT ANYONE, ANYWHERE, IN ANY COUNTRY CAN PURCHASE THE DATA AT EQUITABLE PRICES.

4) ALL NECESSARY LEGISLATION AND APPROPRIATIONS BE ENACTED AT ONCE TO IMPLEMENT THESE RECOMMENDATIONS.

THE LAND REMOTE SENSING SATELLITE ADVISORY COMMITTEE UNANIMOUSLY ENDORSES THIS REPORT AND ITS RECOMMENDATIONS AND OFFERS ITS CONTINUED ASSISTANCE TO SECRETARY BALDRIGE IN THE IMPLEMENTATION OF THIS REPORT.

REAGAN TO ANNOUNCE LANDSAT, WEATHER SATELLITE COMMERCIALIZATION

President Reagan is expected to announce within a month a decision to commercialize both Landsat and the civil weather satellites, and possibly future ocean remote sensing satellites, sources told The DAILY yesterday.

A decision was reached Wednesday by the Cabinet Council on Commerce and Trade (CCCT) which is headed by Commerce Secretary Malcolm Baldridge. The results from the council meeting were embargoed.

Dr. John H. McElroy, the National Oceanic and Atmospheric Administration's assistant administrator for satellites, at an American Oceanic Organization meeting in Washington yesterday refused to discuss details of the CCCT meeting. McElroy did say that a "Presidential decision is imminent" and that "this Administration would not back away from commercialization."

McElroy also said he would expect commercialization to involve a competitive process. Even if the operational parts of the remote sensing systems are taken over by private industry, NASA will continue to be an essential element of the system, responsible for long term, high risk research, he added.

The decision to commercialize weather satellites with the land remote sensing satellites came as good news to several companies that had proposed turning the weather satellites over to the private sector when NOAA asked for industry responses earlier this fall.

Comsat Corp. had submitted a proposal to commercialize Landsat, the GOES (Geostationary Operational Environmental Satellites) and TIROS (Television Infrared Red Observation Satellite) systems immediately. Environmental Satellite Data, Inc., had advocated the commercialization of GOES. RCA proposed to lease GOES and TIROS for 12 years with the government processing all data and furnishing launches. The RCA proposal had reservations regarding tax laws and accounting principles.

Many questions remained unanswered on how to implement a decision to commercialize, such as whether to transfer all systems as a package or to separate them. The timeframe of the turnover and the issue of whether to transfer entire systems at once or transfer portions in phases remain unclear.

NOAA has commissioned three studies on commercialization, and the results will be available from the first in February and the other two in April, McElroy said. These studies, as well as input from the Department of Defense and the State Department, will be used by NOAA to determine how to proceed with commmercialization. McElroy and Congress will have a substantial input into the process as well, and expects hearings on commercialization to be held in April or May.

The Defense Department is concerned about turning over remote sensing systems to the private sector because of the high quality of sensors now in operation and the implication of the available data to national security. The State Department is concerned with remote sensing as a foreign policy issue and tool.

* * *

Value of Landsat Not in Profits to Be Made from It

NASA programs tend to be known and remembered only by their flight hardware, and the Landsat program is no different. But when judging the value of commercializing Landsat, the satellite sinks to secondary importance. We are really talking about the merits of turning over to private industry the Earth Resources Survey Program down here on the ground. Moreover, we are not talking about NASA alone. The program is a joint effort of all the natural resources agencies, including the Agency for International Development. The resources of concern are the major food and fiber crops, the minerals, the air and water, and the environmental quality cause and effect issues for each.

The program came on the scene during the Apollo program. All of the early instrument design was done as a part of the Apollo Applications Program and much of the early mission scenario work was funded the same way. When most of the major Apollo procurement was completed, a concerted effort began to reduce the NASA budget. The applications program received the most rigid of reviews under Program Planning and Budgeting—a zero-base budgeting procedure started by McNamara and the nemesis of all program managers.

The value of the program discovered in those studies is totally unrelated to the "profits" to be made in any commercial venture that has received serious consideration by the government. An overture was made to the government concerning a proprietary commercial venture in mineral resources, but the probable international complications made it unattractive. The U.S. still maintains an "open sky" policy, and a proprietary venture would run counter to it.

Several industries have studied a commercial Landsat venture. Lockheed and General Electric have both concluded that there is no profit to be made unless two conditions prevail: that the government procure and operate the space segment, and that the government agree to underwrite the cost of the ground segment by committing to purchase imagery at a price which would fully amortize the ground segment in some reasonable time.

Comsat has presented the most interesting initiative. Comsat probably came to the same conclusions as Lockheed and General Electric. Comsat, however, saw that if the government coupled Landsat with Metsat, the assured Metsat market would likely carry the Landsat market during its development.

NOAA's reaction is unfavorable for two understandable reasons. NOAA satellites back up the military meteorological satellites. And NOAA has long participated in international meteorology programs in which it must freely share data. It believes a non-governmental agency should not be vested with the military mission support and that failure to honor treaty commitments would not be in the best interests of the U.S. even though those commitments might be considered just "working arrangements." NOAA further argues that the Metsats are concerned with health and safety of the general public, and that this function properly belongs to the federal government. It attributes no such importance to Landsat, when, in fact, Landsat has been used by the U.S. Army Corps of Engineers for its National Dam Survey, very much a health and safety issue to people living downstream. If safety were broadened to include security, it would appear that the ability of Landsat to monitor crops around the globe is clearly a safety issue.

The various proposals have carefully avoided the issue of "added value"—the difference in worth between the data and the information derived from the data. The proposals deal only with the ownership of the data delivery systems. Presumably, the owner would only deliver digital and analog imagery and other data and leave extraction of information from it to the government agency customers and the value-added industry.

Other agencies with a vested interest have not taken public positions. Probably OMB wants to have someone pick up the whole program at its own risk with no guarantees by the government to buy data and certainly not at an inflated price. NASA seems the most detached. During the recent Shuttle flight of the first synthetic aperture radar designed to look at the terrain, NASA made not a single attribution to the program which created it—the Earth Resources Survey.

Not a single person or institution has written about the Landsat program in the context of the national interest. NOAA did an admirable job of defending a continued federal Metsat program but not Landsat. Since it is now the official spokesman for Landsat its position is difficult to understand except as the grim team player showing up for hearings having been properly admonished about the official position. **Archibald B. Park**, National Resources Consulting Services

Source: Astronautics and Aeronautics, Feb. 1983, v. 21, no. 2, pp. 12-16.

French Marketing Services Of Spot Satellite Network

Paris—France's developmental Spot satellite earth observation program will be represented by a commercial marketing group similar to Arianespace, the organization that has led the expanding sales campaign for Europe's multinational Ariane launcher. Supported by a sales network of the privately operated Spot Image company, France intends to make rapid penetration into the worldwide imaging marketplace with the Spot satellite network, which is scheduled to begin operations in 1984. France expects to sell the satellite's multispectral and panchromatic (black and white) images to users throughout the world, while certain countries will be served by their own ground receiving stations operating in commercial agreement with Spot Image.

One of Spot Image's first goals is to establish a U.S. subsidiary for the American market—a region representing prime sales opportunities for satellite images.

Although program officials said they do not consider Spot as a head-to-head competitor with the U.S. Landsat satellite system, the data from Spot will be similar to that available from Landsat. The French officials said they have found a market for Spot data among those users seeking a truly commercialized system rather than the Landsat operation, which functions through the U.S. federal government bureaucracy. Many of these potential Spot clients have become concerned about future Landsat program handling, particularly in light of the project's current uncertainties under the Reagan Administration, officials said.

It is against this background that France will make its first entry into the civilian imaging market when the initial Spot satellite is orbited by an Ariane 2 launcher in 1984. This first Spot spacecraft continues in its development phase, and the French government recently approved production of a second Spot to guarantee users the continuing availability of Spot services through the 1980s.

Optical Instruments

Spot will be based on a basic multimission platform design that will be fitted with two identical high-resolution visible (HRV) range instruments. The optical instruments will have a 20-meter (65.6-ft.) resolution in the multispectral mode, while a 10-meter (32.8-ft.) resolution will be possible with the black and white imaging. Spot's multispectral mode uses green, red and near infrared bands selected to provide several mission objectives, including:

- Consistent relationship between spectral reflectance and vegetational properties.
- Good discrimination within areas of vegetation and within different soil types.
- Compatible interpretation of spectral signatures obtained by the Spot satellite and by Landsat D's thematic mapper.
- Improved radiometric sensitivity and resolution for surface-water work.
- At least one spectral band to provide some water penetration.

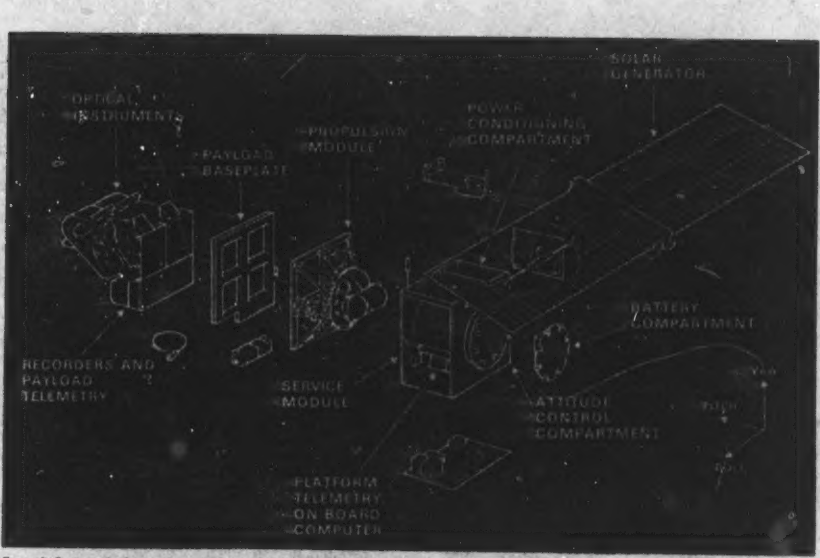
The Spot data is expected to find a market among companies and agencies involved in such activities as oil and mineral exploration; topographic and land use mapping; crop and environmental monitoring; coastal zone studies, and general research activities.

In addition to the basic satellite images, ground processing of Spot images of the same area, taken during two different orbital passes, can be used to create stereo images. Another ground processing capability is the combination of the 20-meter-resolution multispectral images with the 10-meter-resolution panchromatic images. This combination produces a multispectral product with the appearance of an enhanced resolution beyond that of the basic multispectral image.

U.S. industry personnel who have been monitoring France's evolvement of Spot said they expect the country to make a successful market entry as a result of their marketing structure and the satellite's development. "They really will be offering a commercialized product with the service tailored for users," one U.S. government official said. "By using a system in which France's government is involved in program development, and then by splitting

Galileo Probe Model Undergoing Tests

Model of Galileo probe is prepared for vibration testing at various frequencies to simulate launch at Hughes Aircraft Co.'s Space and Communications Group facilities in El Segundo, Calif. The Galileo probe and its companion orbiter being built by the Jet Propulsion Laboratory are scheduled to explore the Jovian atmosphere in the late 1980s. The probe aft cover (facing down in the picture) and the aeroshell (facing toward the top of the photo) separate after entry into the atmosphere, allowing the 30-in.-dia. descent probe inside to begin its atmospheric experiments, results of which will be relayed to the orbiter for transmission back to Earth. The probe is protected by General Electric's thermal control system consisting of Du Pont's Kapton tape treated with vapor-deposited gold at the top of the probe aeroshell; Sheldahl, Inc.'s electrically conductive insulation blanket, which helps bleed the electrostatic charge off the exterior of the probe, and Kapton tape treated with vapor-deposited aluminum on the probe aft cover.


SOLAR GENERATOR
OPTICAL INSTRUMENT
POWER CONDITIONING COMPARTMENT
PROPULSION MODULE
PAYLOAD BASEPLATE
BATTERY COMPARTMENT
RECORDERS AND PAYLOAD TELEMETRY
SERVICE MODULE
ATTITUDE CONTROL COMPARTMENT
YAW
PITCH
ROLL
PLATFORM TELEMETRY ON BOARD COMPUTER

France's Spot earth observation satellite is detailed in this exploded view of the spacecraft. Its imaging payload consists of two identical high resolution visible (HRV) instruments positioned side by side at one end of the satellite. Scale of the spacecraft in this drawing can be estimated by the 2 × 2 meter (6.5 × 6.5 ft.) size of the payload baseplate.

off the actual marketing function, they have the best of two worlds. Meanwhile, we in the U.S. seem to be tripping over ourselves on the handling of Landsat, and the user community cannot help but be concerned about the *future* of Landsat," the official said.

France maintains the primary Spot program management, development and hardware roles, but the system also includes the participation of Sweden and Belgium through their contribution of space- or ground-based hardware.

Sales Organization

For the Spot image-marketing operation, France will establish the sales organization as a private company, with France as the largest shareholder. This follows the setup of the Arianespace group, which has operated the sales drive for Europe's multinational Ariane launcher program.

As with Arianespace, Spot Image chairman duties will be handled by a ranking member of France's national space agency CNES (Centre National d'Etudes Spatiales). Gerard Brachet, CNES director of applications programs and the leading program-level manager during Spot's early development, will take the Spot Image chairmanship when the organization formally is established. Brachet said he will continue in the two management roles until the period when the initial satellite is launched, at which time he will shift full-time to Spot Image activities.

Spot Image will have assets of about 25 million French francs (approximately $4.6 million), with CNES holding about 34% of the company's shares. Approximately 10% will be held each by French aerospace industry companies Matra and Societe Europeenne de Propulsion (SEP), which both have key Spot program involvement. Shareholdings of about 10% each will be held by three French institutions: Institut Geographique National (IGN), Institut Francais du Petrole and Bureau de Recherche Geologique et Miniere.

Additional holdings will be with Sweden and Belgium, and remaining portions will be held by the banking organizations that will be involved in providing cash flow and financing arrangements for Spot Image.

Brachet said the overall Spot Image organization should be in operation by early this year and will be headquartered in its own building located close to the CNES space center facility near Toulouse in southern France. Spot Image initially will have a staff of about six or seven members and is expected to increase its staff to 40-50 persons by the time Spot 1 is launched in 1984.

Brachet said the decision was made to establish Spot Image's operations now because it was believed the users market had not yet been developed properly, and a period of advance work was necessary prior to the 1984 launch.

"There has not been the proper commercial organization in operation before us, and we feel preparation work is needed to make the development work," Brachet said.

For the U.S. marketing aspects, Spot Image will establish a division to serve North America and will operate a toll-free 800 area-code telephone number with staff to provide information on the system.

Starting Date

Target date for the start-up of the U.S. subsidiary is mid-1982.

A number of companies already have indicated a strong interest in the Spot data, Brachet said, and the U.S. Spot Image subsidiary will pursue these customer possibilities. He said the customer-oriented approach of the marketing group, combined with uncertainties about the future of the U.S. Landsat satellite image program, have made a Spot a strong contender for sales in the U.S.

Spot's central control facility will be the CNES space center near Toulouse, and this facility will be used to receive direct transmissions of the spacecraft's earth coverage when it is in sight of the station, as well as images recorded earlier on the Spot on-board tape recorders. A second Spot ground station in Kiruna, Sweden,

Simplified drawing of Spot shows the general configuration of France's new earth observation satellite. The satellite utilizes a basic bus design, to which two high-resolution visible optical instruments are integrated. The basic Spot spacecraft bus can be adapted to other missions, and it has been specified for use in the proposed French SAMRO military observation satellite as well as for ESA's ERS-1 (earth resources 1) spacecraft.

also will receive direct satellite coverage transmissions as well as the tape recorded data. These data will be the main marketing products for Spot Image.

Other Spot distribution will be handled by countries operating their own ground stations that will receive data when Spot is in range of their antennas. These countries will have data reception agreements with CNES, plus marketing agreements with Spot Image, which will permit data distribution within their own countries.

Ground Stations

Ground-station receiving facilities that potentially could receive Spot data are in operation or are being established in a number of countries, in connection with the Landsat program. These include such countries as Canada, Brazil, Argentina, South Africa, Bangladesh, Japan and Australia. Another facility is being built in Thailand, one is proposed for China, and several additional installations are in various stages of discussion or approval.

French representatives have entered discussions with most of these countries regarding the possibility of incorporating Spot in their image-handling operations.

"We feel many of these stations will enter into agreements with us for the handling of data," Brachet said. "This will provide Spot with distributors in the key user countries of the world."

The stations will have exclusive rights to market data within their own country, and they will not have competition in their home market from the Spot Image organization. The agreements between these nations' stations and CNES concerning the receiving authority agreement are expected to involve payment arrangements including:

- A basic subscription fee for the right to receive Spot data.
- A basic program fee based on minimum coverage required for their area of coverage.
- Additional fees for specific programing if more frequent coverage is required from a certain area or if other specific satellite services are needed by the station to fulfill the needs of its clients.

"We are structuring the program so that the fee paid by receiving stations to CNES will basically be proportional to the amount of data received by them—we do not want a pricing structure that requires them to pay for data not ordered," Brachet said.

"This is expected to be linked to the number of scenes transmitted to the ground station, with each Spot scene covering a 60 × 60-km. [37 × 37-mi.] area."

The pricing approach differs from the Landsat charge structure, in which stations pay a flat fee that is not dependent upon the maximum or minimum amount of data received, Brachet said.

It is anticipated that a special computer arrangement will be established that will enable the participating Spot ground receiving stations to transmit their daily spacecraft requirements to CNES, where the overall satellite programing will be handled accordingly each 24 hr. This computerized "mailbox" will allow the receiving stations to update their satellite coverage requests daily on the basis of their needs and will allow CNES to program the spacecraft, taking these requests into account, along with the spacecraft power, instrument and other technical requirements.

"We feel this daily programing input capability on behalf of our ground station network will allow it to have the greatest flexibility," Brachet said. "The type of approach is already used to a certain degree for our Argos data collection satellite system, and we have found the Argos program to have worked very well.

"Through this system, the work of the spacecraft will, in effect, be programed by the receiving station network," he said.

"The system also will provide the opportunity for CNES to communicate with the receiving stations through a daily 'newsletter' in which the stations are informed about the spacecraft's operation and whether there are any particular situations they should be aware of."

User stations now in operation for Landsat will require modifications to receive the Spot X-band data, but some facilities already are planning these updates, and others are considering similar steps as the result of the general shift toward X-band data transmissions for the new Landsat D and other spacecraft such as Spot. Some of the new stations probably will be constructed initially with X-band reception capability, Spot program officials said.

For Spot Image's own marketing activities, the group could use data obtained in several methods. One method would be to use the data transmitted directly to the French and Swedish stations while the satellite made its images when in range of these stations.

Another method would be to employ a downlink of data recorded when the spacecraft was out of range from the two facilities. The tape recorder would be used over such areas as oceans, where images of interest could be obtained, but where no ground station exists for direct real-time transmissions.

Third Party Sales

In cases when a client wants data from a country where one of the foreign Spot ground stations already operates, Spot Image could contract with that station to use its images for sale to the third party. Spot Image would not be in competition with the foreign ground station in this situation because the station does not have the authority to market outside of its home market.

"We normally would contract with the ground station to sell images from its coverage area to another user outside of that country. We generally would do this, rather than use the tape recorder and our French or Swedish stations, because we'd try to save the tape recorder for areas where no station receiving capability exists," Brachet said.

For the overall Spot pricing procedures, CNES will charge Spot Image and the participating foreign ground stations a fee of about one French franc per megabit of data transmitted by the spacecraft. A 60 × 60-km. (37 × 37-mi.) Spot scene represents 220 megabits of data—so the CNES charge per Spot scene is estimated to be about 220 francs (approximately $39).

Spot Image and the foreign stations then will establish their own fee schedules for the final product they will deliver to clients, taking into account their own costs, which include preprocessing, receiving station operations, archiving and marketing expenses. ☐

Remote sensing satellites

French plans for spot satellites

The French national space agency, the Centre National d'Etudes Spatiales (CNES), believes there is money to be made by remote sensing from space. Sales of data recorded by the two Spot satellites, France's first national remote sensing satellites due for launch in 1984 and 1986, are expected to offset the capital cost of the satellites' development and running costs in about ten years. Responsibility for earning the revenue will rest with Spot-Image, the independent company created early last month to market Spot data worldwide.

CNES's approach to the commercialization of remote sensing data differs markedly from that in the United States. The US National Aeronautics and Space Administration (NASA), like CNES chiefly a research and development agency, has been an unwilling operator of the service forced upon it when data from the early Landsat satellites proved commercially attractive. Potential users have complained that NASA was sometimes insensitive to their needs.

NASA will indeed be administering the distribution of data from Landsat-D, the latest satellite in the series launched last month, and from Landsat-D', its successor, but beyond 1987 the Reagan Administration has insisted that NASA will have to get out of commerce so that the operational service will have to be taken up by private industry. Thus the fortunes of Spot-Image will be keenly watched in the United States as well as by the European Space Agency, now debating how to make available data from its planned remote sensing satellite ERS1, and the British government, which is contemplating a major effort in remote sensing.

Spot-Image's main shareholders are CNES with a 34 per cent holding, three French government agencies each with 10 per cent — the Institut Cartographique Nationale, the Institut Français du Petrole and the Bureau de Recherche Géologique des Minières — and two companies, Matra and Societé Européen de Propulsion, with 7.5 per cent each. Organizations from Sweden and Belgium which have collaborated to some extent on Spot, will also have small sharehodings. Spot-Image will buy data from CNES and sell them.

NASA's early experience in selling remote sensing data, however, seems not to augur well for Spot-Image. Although there has been great interest in Landsat data, there has been no prospect that fees would match development costs. But, according to Gérard Brachet, director-general of Spot-Image, the market for data from the second generation of remote sensing satellites should grow by leaps and bounds — he reckons that Spot should earn about $900 million, to cover development and running costs, within ten years.

The chief advantages of Spot and Landsat-D over earlier generations of remote sensing satellites is their increased resolution and number of spectral bands. Spot, for example, whose chief instrument is a multilinear array, will observe in three bands in the infrared and visible regions of the spectrum with a ground resolution of 20 m and in a broad band with 10 m resolution. Stereoscopic images are also available.

Spot data will be received and interpreted in Europe at ground stations in Toulouse (France) and Kiruna (Sweden). Spot-Image plans to turn round data within 48 hours for dispatch to users. The charge for one scene in digital form is expected to be about $1,000, but the fee for a photographic image has yet to be worked out, although it will be less. Brachet is confident that prices will compare favourably with those for images generated by the multi-spectra scanner aboard Landsat-D although comparisons with the thematic mapper, Landsat-D's most innovative instrument, are more uncertain.

Spot-Image is negotiating with some countries to receive Spot data direct via their own Earth stations, in which case there will be a copyright fee of only about FF220 ($40) per scene, less than the cost of images bought from Toulouse or Kiruna. The apparent discrepancy is explained, according to Brachet, by the prospective loss of about 70 per cent of potential images due to cloud as well as the cost of processing images.

Judy Redfearn

COMMERCIALIZATION OF THE CIVIL SPACE REMOTE SENSING SYSTEMS*

- A Review

I. INTRODUCTION

The civil space remote sensing systems include the land remote sensing, polar-orbiting environmental (weather), and geostationary environmental satellites. There are five operational satellites in orbit and eight satellites in various stages of manufacture, test, or storage. The systems also include data processing and distribution facilities at Greenbelt, Maryland; Suitland, Maryland; Camp Springs, Maryland; and Sioux Falls, South Dakota; and tracking facilities at Gilmore Creek, Alaska, and Wallops Island, Virginia. The acquisition costs for this equipment were nominally $1.6 billion, not including initial research and development or the costs of preceding satellites in either the land or environmental series.

The central issue that now has spanned two Presidents' Administrations is whether all or any part of this complex of systems should be transferred from the Government to private ownership. The Carter Administration initiated the examination of the issue, but elected to limit commercialization to the land satellites; the current Administration reiterated the Carter position on land satellites and added the environmental satellites to the examination. The following sections will review the issues and options associated with such a transfer, and recent processes that have been initiated to address those issues.

II. SPACE POLICY BACKGROUND

President Carter's decision on operational civil space remote sensing was the result of a two-year review of the nation's space policy. This effort included the formation of the Policy Review Committee (PRC) on Space as the senior interagency body to coordinate space matters, to replace the Under Secretaries Committee (chaired by State) that was used as the policy coordinating body under the Nixon and Ford Administrations. In May 1978, President Carter announced that the United States would encourage domestic commercial exploitation of space capabilities under appropriate U.S. authorization and supervision. In October 1978, the President made a commitment to ensuring continuity of land sensing data, and reiterated that commitment in his March 1979 Science and Technology message.

From October 1978 through the summer of 1979, the Executive Branch examined a range of issues including the potential for integrating civil and military space remote sensing systems and greater private sector involvement in those systems. This examination led to a Presidential directive issued in November 1979 that provided the framework for civil operational remote sensing (see Appendix A). The chief policies stated by the directive were:

- Assignment of the Fedefal management role for civil space remote sensing to the National Oceanic and Atmospheric Administration (NOAA).

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*Assembled by John H. McElroy, Assistant Administrator for Satellites, National Oceanic and Atmospheric Administration, August 1982

- o Continuation of separate military and civil polar-orbiting environmental satellites.
- o Establishing a goal of eventual transfer to the private sector of the land remote sensing system.
- o Commitment to continuity of land remote sensing data through the 1980s.

This process is described in greater detail in the NOAA document describing the conclusions of the Satellite Task Force.[1]

Shortly after President Reagan entered office, it was announced that the Administration would terminate the commitment to land sensing satellite data continuity through the 1980s on the basis that:

> It is the Administration's judgment that the present NASA investment in Landsat is sufficient to permit evaluation of operational uses of Landsat data and, if these uses are cost effective, to attract a private sector owner/operator.
>
> NASA's program to develop, launch, and test the two additional satellites already in manufacture (Landsat D and D') will continue as previously planned. Expansion and extension of the U.S. civil land remote sensing program, beyond that already funded by NASA, is inconsistent with the need for across-the-board fiscal restraints....

The two additional satellites, frequently referred to as Landsat D" and D"', then were deleted from the budget.

In response to an inquiry from a private firm the Administration then elected to widen the discussion of commercialization to include the civil weather satellites. The addition of the civil weather satellites increased the complexity of the process. The then Deputy Director of the Office of Management and Budget asked the Cabinet Council on Commerce and Trade (CCCT), a senior Cabinet-level policy-making body chaired by the Secretary of Commerce, to address two issues (Appendix B):

1. What is the best mechanism to implement the current policy of transfer of civil land remote sensing systems (Landsat) to the private sector as soon as possible?
2. Should the Administration consider simultaneously private sector transfer of both civil weather and land remote sensing systems?

The CCCT has met a number of times on these issues, seeking additional information and impact analyses, but has not yet forwarded a recommendation to the President. The Chairman of the CCCT is expected to do so after he has reviewed private sector views on these issues.

In parallel with the CCCT activities, the Department of Commerce formed an advisory committee representing a wide cross-section of non-Federal experts on space remote sensing including members of the business and investment community (see Appendix C) to advise the Secretary on commercialization of the Landsats. In addition, an interagency group was formed--the Program Board on

Civil Operational Land Remote Sensing from Space--so that other agency views could be expressed to the Secretary. The charter of the Program Board is given in Appendix D. Also in parallel, the President's Office of Science and Technology Policy (OSTP) was chartered to develop the Administration's space policy.

The advisory committee met in June 1982 to review the status of the Landsats and plans for commercialization. The Secretary, also asked them to review the weather satellites, as another means of collecting private sector views. The committee passed two resolutions (see Appendix E); the chief one was a recommendation that the Secretary formally solicit industry's inputs so that they would have a base of information from which to develop their recommendations. This recommendation has been accepted by the Secretary and a formal Request for Information (RFI) for publication in the Commerce Business Daily (CBD) has been coordinated with all affected Federal agencies and published (see Appendix F). A more detailed review of that process is given later in Section XIII.

On July 4, 1982, President Reagan announced his space policy. It defines the Department of Commerce role by stating (see Appendix G):

> The Department of Commerce, as manager of Federal operational space remote sensing systems, will: (1) aggregate Federal needs for these systems to be met by either the private sector or the Federal government; (2) identify needed research and development objectives for these systems; and (3) in coordination with other departments or agencies, provide regulation of private sector operation of these systems.

The Policy addresses the private sector role in stating:

> The United States Government will provide a climate conducive to expanded private sector investment and involvement in space activities. These space activities will be authorized and supervised or regulated by the government to the extent required by treaty and national security.

The policy also establishes a Senior Interagency Group (SIG) for Space for interagency coordination and policy development. It replaces the PRC(Space) of the Carter Administration. Chaired by the President's National Security Advisor and made up of the Deputy Secretaries of key Departments, it is likely to become a forum for national security and foreign policy issues related to civil remote sensing. The formation of the SIG(Space) denotes an elevation of the review of space matters well above that used in past Administrations.

III. OUTER SPACE TREATY

In addition to the national policies reviewed above, the United States is a signatory to the Multilateral Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies--commonly referred to as "The Outer Space Treaty." Article VI states:

> States parties to the Treaty shall bear international responsibility for national activities in outer space...whether such activities are carried on by governmental agencies or by non-governmental entities....

> The activities of non-governmental entities in outer space...shall require authorization and continuing supervision by the appropriate State Party to the Treaty.

This article appears to mandate, as a matter of treaty obligation, regulation of activity in space by private entities, although the terms "authorization" and "continuing supervision" are subject to interpretation.

The discussion then provides one context for the previously quoted statement from President Reagan's Space Policy which refers to private sector space activities being "authorized and supervised...by the government to the extent required by treaty and national security." It also provides one of the rationales for establishing a single Federal focal point for the management and regulation of a private sector entity.

IV. FEDERAL VERSUS PRIVATE ROLES IN RESEARCH AND TECHNOLOGY

The President's OSTP used the Annual Science and Technology Report to the Congress: 1981[2] to outline basic principles for Federal involvement in research and technology. Among other principles:

> ...there is less justification for a dominant Federal Government role in near-term applied research and, especially, development, except in such areas of primary Federal responsibility as defense, space, and environmental regulation, and in heavily regulated technologies. Other areas in which the Government has a more limited role to play include those of shared responsibility...where the broad societal benefits justify Federal involvement and those areas of development where the Government is the sole or dominant buyer.

Thus, commercialization does not rule out continued mission-related applied research and development on civil space remote sensing by Federal agencies. This is particularly germane to future advanced research and development in space applications by NASA, satellite meteorology in NOAA, satellite-aided mapping in the Department of Interior's United States Geological Survey (USGS), and others.

At the other extreme, essentially no Federal role is permitted by this policy in non-mission-related research and development--or activities which could be construed as product-related and unconnected to agency requirements. Such activities are left exclusively to the private sector.

V. FEDERAL VERSUS PRIVATE ROLES IN OPERATIONS

The fundamental principle upon which Government policy is based is that the Government should not compete with its citizens. This policy was first articulated in 1955. The current guidelines for implementing this policy are contained in OMB Circular A-76, which states that the Government should not engage in commercial or industrial activities where the private sector can provide them more efficiently and cheaply. The circular, and the implementing guidelines derived from it by the Federal agencies, gives procedures for the acquisition of commercial or industrial products and services needed by the Government.

Four key paragraphs in this Circular are relevant to these discussions:

> Purpose - This Circular establishes the policies and procedures used to determine whether needed commercial products and services should be obtained by contract with private sources or in-house using Government facilities and personnel.
>
> Policy - The Federal Government shall rely on competitive private enterprise to supply needed commercial products and services.
>
> A Government commercial activity is a function operated and managed by a Federal executive agency and providing a product obtainable from a private source.
>
> A Private commercial source is a private business, university, or other non-Federal activity...which provides a commercial product or service required by Government agencies.

The Circular provides in its appendix "a representative, but not comprehensive" listing of such activities. Listed below are the section headings in the Circular's list:

Audiovisual Products and Services
Automatic Data Processing
Maintenance, Overhaul, and Repair
Systems Engineering, Installation, Operation, and Maintenance
Manufacturing, Fabrication, Processing, and Packaging
Real Property
Industrial Shops and Services
Health Services
Transportation
Printing and Reproduction
Research and Development
Office Services
Security
Food Services
Other Services

Some situations are covered by straightforward application of A-76 procedures. For example, if a Federal agency required maintenance services and either has a civil service staff in place or would have to establish one, the comparison between that mode and employing a private contractor is easily accomplished-at least in principle. In another instance, a comparison can be made between a Federal agency's continuing to use in-house printing facilities and contracting for those services from a private firm. The civil remote sensing systems are far more complex than these examples.

A recent paper[3] by two private sector authors suggests that the Government policy must be even more aggressive than might be interpreted from the A-76 guidelines. They suggest it is not sufficient to avoid competition with private entities (who are presumed to have existing personnel and facilities capable of carrying out the task), but that it must also create the capabilities in a firm, transfer to it the equipment necessary to carry out the activity, and allow sufficient time for the firm to hire or train the people needed for the activity. This would be a much stronger interpretation of OMB Circular A-76 than has been taken in the past, and would indeed denote a significant policy shift if adopted.

One aspect of the above issue is whether the Government is obliged to pass beyond a contractual arrangement in which Government property is used by a contractor (if needed) under normal Government-furnished equipment (GFE) provisions, or to move to the creation of a profit-making entity through transfer of ownership of Government assets. If the latter process is undertaken, it immediately raises the further issue of how to set a price on Government assets. As noted in the introduction to this paper, the acquisition cost of the current physical assets was $1.6 billion. Replacement costs--taking into account inflation in the years since a given item of equipment was purchased--would be a higher value. Assessed value of the assets--taking into account age of the equipment and depreciation--would presumably result in a third price. One alternative to any of these assessment approaches would be to treat the Government assets as "sunk costs" and ask no price at all--as a means of minimizing the financial burden on a private firm. Another alternative would be to employ an adjusted rate schedule for data purchases to allow the Government some recoupment over a period of years for its investment without creating the need for large initial financing by the firm. Obviously transferring Government property to a private firm without recovering fair market value could be characterized as subsidization. Finally, no current legislative authority permits carrying out such a transfer.

VI. FACTORS APPLICABLE TO REGULATION OF LAND AND ENVIRONMENTAL SATELLITES: DATA USES

The Landsat system provides data which are used by Federal agencies, but also by other domestic and foreign users as well. While the data are important to present users, brief interruptions in data services do not carry the potential for catastrophic impact, because they are not critical to protection of life and property. Further, a nominal 50 percent split exists between Federal and other users--thus, a significant non-Federal market exists. Also, projections exist for a substantial growth in the non-Federal market as applications become proven. Therefore, the combination of the lack of a catastrophic impact and the desire to not hamper the potential market growth militates toward a minimal regulatory regime.

The environmental satellites, on the other hand, provide hurricane and severe storm data for the development of public warnings. They also provide data to forecasters in the National Weather Service, Department of Defense, and the international community. The potential effect of interruptions or changes in service on public health and safety, national security, and foreign relations is quite different from that which would result from similar changes in the Landsat system. Finally, nominally 95 percent of the data is delivered to Federal agencies. In spite of the data also being available to the private sector at no cost for some twenty years (and thus relieving private industry of any need to fund the high-cost part of the system), no substantial value-added industry has developed or is projected for weather products. Thus, even if modest growth is attained in the private sector, Federal needs will dominate the system and its character for the foreseeable future. For the above reasons, the regulatory regime for the environmental satellites could not be as minimal as that for the Landsat system.

VII. FACTORS APPLICABLE TO REGULATION OF LAND AND ENVIRONMENTAL SATELLITES: NATIONAL SECURITY CONSIDERATIONS

For Landsat, and the follow-on missions that a private sector entity might propose, the sensing parameters must be screened to ensure that they do not disclose militarily sensitive information or technology. The capabilities of the sensing system that might be reviewed include: spectral resolution, center frequency, and tunable range; spatial resolution; geographic coverage; timeliness of data availability, tasking procedures and controls, etc. It is likely that a regulatory regime would be proposed for prior approval of such characteristics. Clearly the issue becomes more complex if a private firm is foreign-owned or a multi-national enterprise.

National security considerations must, however, be tempered in the regulatory process. Due regard must be given to the market in which the private entity is operating. Sensor characteristics must be such that a private entity's competitive position is, at a minimum, maintained in the remote sensing market. National security considerations must be weighed against competition from satellite systems such as SPOT or ERS-1 when reviewing sensing parameters. Standards must not be set that would erode seriously a private entity's ability to compete successfully in the satellite remote sensing market.

For the environmental satellites, there is the broad set of issues related to service by the satellites to the Department of Defense (DoD). This has three aspects: (1) priority service to DoD under either normal circumstances or emergencies, (2) denial of civil satellite use to hostile powers, and (3) transfer of command and control of the civil satellites to DoD in Presidentially-declared emergencies. Although the role of the civil satellites is frequently referred to as that of a backup to the Defense Meteorological Satellite Program (DMSP), the activity is an integral part of DoD weather forecasting and not only a backup.

The relationship between defense and civil weather satellite systems requires flexibility and responsiveness. Satellites are only one element, although an important one, of global cooperative weather observing and forecasting systems. Best utilization of that system involves control and modification of criteria for satellite replacement (i.e., what instrument failure or combination of failures necessitates replacement), orbital parameters (to fit the need of synoptic analyses or other requirements), and satellite instrument complements. The civil and military polar-orbiting satellite systems currently share the use of the same satellite design, although the instrument complements flown on the satellite differ, and interlocked shared data processing systems are being implemented to reduce overall costs. The Government must influence the above items--particularly such critical parameters as equator crossing time. Unilateral control of instrument, satellite, or orbital parameters by a private firm could adversely affect operations extending well beyond the weather satellites. Changing circumstances in either the military or civil systems can require rapid changes--and often in an unpredictable manner that cannot be anticipated in simple data purchase contracts. This paragraph is not intended to state that commercialization of the civil weather satellites is impossible--only that the freedom of action of a private firm is likely to be restrained.

These considerations, for both the land and environmental satellites, introduce an element of supervision that will be required in any commercialization of the civil remote sensing satellites.

VIII. FACTORS APPLICABLE TO REGULATION OF LAND AND ENVIRONMENTAL SATELLITES: INTERNATIONAL RELATIONS CONSIDERATIONS

In addition to the principles stated in the Outer Space Treaty earlier, a number of concepts have guided United States space remote sensing activities: (1) The U.S. does not agree to the principle, often raised in the United Nations, of the right of prior consent--in which permission of the sensed state would be required prior to data being taken by a sensing nation or disseminated to a third nation. (2) The U.S. endorses the concept of public, timely, nondiscriminatory data dissemination to all nations. (3) The U.S. does not endorse the concept of a remote sensing satellite system to be managed by the United Nations, although bilateral or multilateral cooperative efforts in this and other areas of space activities have customarily been endorsed. (4) The U.S. participates in the free international exchange of weather data, including weather satellite data, which provides global data vital to the national defense and commercial interests of the U.S. and our major allies.

A foreign policy objective of the U.S. is the encouragement of international acceptance of the U.S. space remote sensing activities--both civil and those related and critical to national security. This has been fostered through the open dissemination of Landsat data for only the cost of reproduction. It has also been fostered by an aggressive policy of sharing the benefits of civil remote sensing technology with other countries. Indeed, President Nixon, in describing the Landsat program to the United Nations General Assembly in 1969, said, "This program will be dedicated to producing information not only for the United States but also for the world community."

International cooperation in weather satellites is even more extensive than in Landsats. While the Landsats provide direct broadcast (unencrypted) readout of data to 11 nations--as well as openly distributing all processed data--the weather satellites openly broadcast their data to nearly a thousand stations in more than 100 countries. A cooperative geostationary satellite network has been established in which two U.S. satellites are flanked by satellites provided by the European Space Agency, Japan, India, and eventually the USSR. Processed weather data from all sources are distributed to over 150 countries participating in the United Nation's World Meteorological Organization. These data distributions are without cost to the user, and in exchange the U.S. receives surface-derived weather data from these nations, also without cost.

While the above international policies could be revised, it is evident that they have served the U.S. well. It is also evident that a private firm cannot be permitted complete autonomy in changing these relations if the systems were commercialized. Instead, protecting the interests of the U.S. would require supervision from the perspectives of maintaining good relations with other countries, securing acceptance of U.S. activities in space, and maintaining the global flow of all weather data.

IX. COMMERCIALIZATION OPTIONS

Commercialization options for the civil remote sensing satellites can involve all or any part of either system. In a broad sense, commercialization can encompass any of the following stages (the stages accumulate from top to bottom):

- Value-added services (already partially commercialized)
- Data processing and distribution
- Spacecraft tracking and data acquisition
- System ownership and operation

The Landsat and environmental satellites can be placed on a parallel or a joint option ladder. A further option ladder would encompass a similar series of options that would culminate in operation of the entire system on behalf of the Government, but with no transfer of ownership. These options are discussed in greater detail in the report of the interagency group on private sector involvement in civil space remote sensing.[4]

X. SUBSIDIES, CROSS-SUBSIDIES, GUARANTEES, AND PRICES

One of the most controversial issues surrounding commercialization is that of subsidies. Subsidies could be in a variety of forms: direct cash subsidy payments; Federal loans or loan guarantees; guaranteed Federal purchases of data services at a volume higher than demand projected by Federal users; Federal purchases at a unit price significantly higher than charged to other users; provision of free services, such as satellite launches; special tax incentives; or other. The Administration opposes subsidies to commercialize civil remote sensing on several grounds.

- Any form of subsidy (whether increasing cash outflow or reducing revenues) is opposed on the basis of budgetary impact on the efforts to balance the budget.

- Subsidies in this area would set undesirable precedents in other areas.

- If a commercial initiative cannot stand the test of the marketplace, it should not be established at all.

The limited market for Landsat data, combined with the possible competition from remote sensing systems owned by or subsidized by foreign governments, has, in the past few years, led to industry's conclusion that the Landsat system cannot be commercialized without a substantial subsidy (in some form) for at least the initial years of a private initiative. The amount and type of the suggested subsidy have varied from company to company, and is usually tied to other policy issues such as the system owner's proprietary rights to data, continued Federal R&D, avoidance of competition from government systems, changes in historical government policies on distribution of data, and other matters.

The Administration's FY 1982 and 1983 budgets contain two land remote sensing thrusts: (1) Major Federal user agencies have requested modest funds to purchase Landsat data, and (2) NASA will continue a low level R&D effort on new sensors. This budget approach implements the OMB position that, if Landsat's commercialization cannot be accomplished without subsidy, the Government will terminate its land remote sensing program with the demise of Landsat D and D'.

The issue of subsidies is, however, linked to national benefits from continuing a U.S. civil satellite land remote sensing capability. It is clear that there are significant national benefits, although their dollar value is debatable. Existing analyses project annual national benefits between a few hundred million dollars and a high of ten billion dollars. Differences in these estimated benefits are caused by different assumptions on U.S. remote sensing capabilities (e.g., two studies assumed 80-meter resolution, and one study assumed 10-meter resolution).

It is also recognized that the Landsat program provides intangible benefits to the nation--benefits that cannot be measured in terms of dollars. These benefits include: contributing to important national and international space policies; promoting vigorous U.S. energy, minerals, and agricultural industries; improving the management of resources on public lands; and supporting the national security interest of the nation.

For a more complete discussion of the tangible and intangible benefits from a continued U.S. land remote sensing system, see Appendix H.

Although subsidies to a commercial land remote sensing system are opposed by the Administration, subsidizing a private venture may be more economical in the long term than continuing the program within the government, if continuing the U.S. capability is determined to be sufficiently important from the national perspective.

The need for subsidies to a commercial supplier of weather satellite data is not as well understood as the needs in the land remote sensing program. Only one major firm has thus far suggested commercializing the weather satellite system, and insufficient information has been provided to project either savings or the need for a direct subsidy.

The Administration advocates the policy that users should bear the full cost of services supplied. The Departments of Commerce and Defense follow this policy in that they, as the dominant users of weather satellite data, seek all the funds needed to provide weather satellite data services through the appropriations process. Likewise, the major Federal users of Landsat data are seeking appropriations to purchase Landsat data starting in fiscal year 1983. Any proposition to commercialize the civil satellite remote sensing systems which requires higher revenues from the Federal users of data from one system (such as the weather satellites) to finance the development of the other system (such as the land resources satellites) appears to be contrary to this policy. It is a cross-subsidy that would be opposed by the agencies whose data costs would be increased to support those of another agency (e.g., the cost to the National Weather Service for weather satellite data could be increased to support the Department of Agriculture's need for Landsat data).

All of the above obviously relates directly to the issue of data prices. Should a firm be allowed to charge whatever it chooses for weather data? Should there be a regulated rate structure for land and/or weather data analogous in some respects to telephone or utility rate structures? These are all interlocked and highly controversial issues.

XI. INSTITUTIONAL ALTERNATIVES, MONOPOLIES, AND DESIGNATED ENTITIES

Irrespective of how the other issues above are resolved, ultimately if commercialization occurs an institutional framework must be created. Some of the issues related to such a framework are addressed in a transition plan developed for Landsat by NOAA.[5] Among the options identified were:

- Private corporation
- Legislatively established for-profit private corporation
- Government corporation
- Federal agency ownership with private sector operation

Related to the issue of institutional framework, is whether a monopoly should be established (de jure or de facto) and a designated entity created to serve Federal needs. If the Government transfers all civil satellite assets to one firm, can another firm compete against that firm successfully? Is a purely laissez-faire environment desirable to promote competition and also satisfactory to ensure the availability of weather data? How is the international interface accommodated? Are the answers to these questions different for land and weather satellites? What mechanism can be implemented to prevent a monopolistic entity from arbitrarily increasing prices for weather data upon which the Government is dependent?

XII. THE CONGRESS

The Congress has continued to show an increasing interest in all of the above topics. A lengthy history of legislative hearings is on the record of both the Senate and the House of Representatives. The tenor of those hearings can be sampled in a recent committee print entitled, "Civil Land Remote Sensing System," prepared by the House Subcommittee on Space Science and Applications.[6] The Congress is obviously intent on following this subject closely.

Clearly, the process of developing legislation to implement any transfer of civil satellites and remote sensing responsibilities will be fraught with controversy about both the substance of legislation and the locus of jurisdiction over such legislation. The number of concerned Congressional committees and subcommittees may be large. Numerous competing views have already been expressed in past hearings, and they will multiply rather than decrease in the future.

XIII. PROCESS AND FUTURE ACTIONS

The announcement shown in Appendix F was published on September 10, 1982. Forty-five days later, on October 22, industry views are due. In parallel, two committees will review those responses. One committee will be selected from the private sector advisory committee listed in Appendix C. A second committee will be assembled from representatives of concerned Federal agencies. The private sector advisory committee will meet later to review the work of its subcommittee and formulate recommendations to the Secretary of Commerce. The Secretary will also be briefed by the Government committee and then formulate the next steps, which may include reconvening the CCCT. It appears that the earliest that the CCCT can meet on this subject to consider these inputs will be late in 1982. It is expected that the CCCT will provide a recommendation to the President, which if approved would in turn lead to the next steps toward commercialization--especially the formulation of proposed legislation.

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Imaging the Earth (I): The Troubled First Decade of Landsat

Landsat-D is about to be launched; if all goes well, problems with the program may be alleviated

This coming July, almost 10 years to the day after the launch of Landsat-1, the National Aeronautics and Space Administration (NASA) will orbit Landsat-D, the first of its second-generation remote sensing satellites. The timing is coincidental but fitting. The spacecraft caps a decade of brilliant technical success by NASA. But frustration among users of Landsat data has marred the achievement.

The conflict between NASA and the users is as old as Landsat itself. The idea for Landsat emerged in the 1960's, in the U.S. Geological Survey under its late director William T. Pecora. The early weather satellites and pictures taken by the Gemini astronauts had shown survey scientists something of orbital photography's power. A single image could encompass large-scale geological features that might take days or weeks to cover with aerial mapping. Better still, such photographs could show features so extensive that they had never been noticed from the ground and that were lost in the patchwork of aerial mosaics.

This is the first of two articles on the history of the Landsat program. Next: the search for a home.

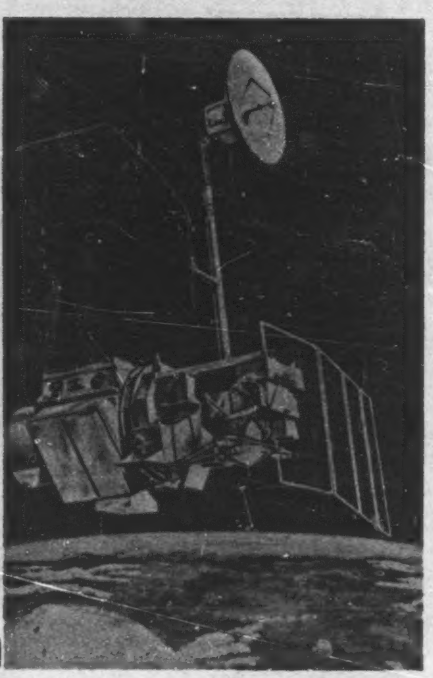
Others were thinking along the same lines. In the Department of Agriculture, for example, Archibald Park and his colleagues were interested in large-scale surveys of crops and forest. Embryonic ideas for an Earth Resources Observation Satellite (EROS) took form as early as 1966, and by 1968 the Interior Department was asking the Office of Management and Budget for money to build it. The answer was "no": space belonged to NASA.

NASA, meanwhile, was still preoccupied with getting Apollo to the moon. Under pressure from its fellow agencies it did agree to develop and launch an EROS satellite. But NASA did not want to get involved in cranking out survey data on a day-to-day basis. Quite aside from the demands of Apollo, NASA's charter (the National Aeronautics and Space Act of 1958) specifically stated that it was to be a research and development agency, not a vendor of services. At a minimum, Interior or perhaps Agriculture, as the prime users, would have to take responsibility for archiving and distributing the data EROS would collect.

The people at Interior had always felt that EROS should have been their satellite anyway, so it was a deal. The system set up then is still in effect today: NASA collects the satellite data at Goddard Space Flight Center in Greenbelt, Maryland, and Interior sells it through the Geological Survey's EROS Data Center in Sioux Falls, South Dakota.

After the pact was made, NASA's once modest efforts in remote sensing research hardware escalated into full-fledged program development. And therein lay the problem. "The minute that NASA stepped in," says one observer, "the program took on a definitive characteristic. NASA is very good at building *things* and managing big programs. Then once it has built those things, having put 10 times the money into developing the instruments as into learning how to analyze the data, NASA just says, 'Here it is community, *use* it.' A prime example today is Landsat-D. They're spending $500 million on the system and you could carry around the money for analysis in a thick wallet."

In fairness, NASA originally presumed that the users of the data would pay for the analysis themselves—a hope not always realized. More recently, the agency has had trouble getting the mon-



Landsat-D in orbit, an artist's conception.

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ey for data anlaysis. (Landsat-D project scientist Vincent Salomonson finds this is a very sore point. The actual figure for anlaysis over the next several years is about $5 million, he says, and most of that money is for checking the integrity and quality of the data, not for applications per se.)

In NASA's hands, EROS became ERTS, the Earth Resources Technology Satellites. ERTS-1 was launched on 23 July 1972. Built into the same spacecraft frame designed for the Nimbus weather satellites, ERTS-1 resembled a stocky ocean buoy, with a pair of rectangular, photovoltaic wings open to the sun. It flew based-down, 900 kilometers above the surface. The polar orbit took the satellite over any given spot on the earth once every 18 days, between 9 and 10 a.m.

The main instrument on ERTS-1, a triplet of television cameras (return beam vidicons) for photographing the earth in color, failed shortly after launch. But disappointment was soon forgotten as the mission controllers at Goddard became entranced with the data coming from the spacecraft's other instrument, an experimental device called the multispectral scanner (MSS).

The MSS had been tested on high-altitude aircraft, but no one was really sure what to expect from it in orbit. A "scanner" mirror rocked from side to side some 13 times per second. By deflecting light from the ground into the detectors, the mirror scanned the scene below in a series of parallel swaths—rather like someone walking along a path while sweeping it with a broom. Its "multispectral" sensors took the spectrum between green light and the near infrared, divided it into four wavelength bands, and measured the brightness of each band separately. The idea was to compare the reflectance of a scene in the various bands and thus identify crops, forests, landforms, cities, and patterns of land use by their "color."

The MSS worked beautifully, recalls Salomonson. "The resolution and the image quality were much better than anyone had expected. It became the primary instrument."

The imagery from MSS, printed in false color in order to include the invisible infrared band, had an eerie and unexpected beauty. There were scarlet forests, red patchwork farms, blue city grids, brown crinkled mountains, and a delicate web of highways. The information content was enormous. Using ERTS-1 images of California, it took just 40 man-hours to inventory 25 separate crops in 8865 separate fields. Agronomists were able to detect and monitor such plant diseases as corn leaf blight. Geologists could take in whole fault zones at a glance. Hydrologists could monitor the Sierra snowpack and could easily inventory surface water in rivers, lakes, and streams. Land use planners could see urban sprawl and strip-mine damage made painfully obvious.

By the mid-1970's, it was not just the original federal agencies who were involved but state and local governments as well. Mining and oil companies were taking notice. Private firms were springing up to analyze the data for paying clients. The demand for satellite remote sensing edged inexorably upward, and NASA, like it or not, began to be drawn into a quasi-operational program.

ERTS-B, the backup for the first spacecraft, was launched on 22 January 1975. To emphasize its utility for remote sensing of the land (as opposed to the oceans or the atmosphere), agency officials renamed the whole program "Landsat." The original ERTS, naturally, became Landsat-1. Landsat-3 followed in March 1978 and is the only one of the trio still in operation today.

Planning for a second-generation scanner had begun as early as 1970. The thematic mapper, as it is now called, advances the 80-meter resolution of the MSS to 30 meters, and senses not just four spectral bands but seven. In agriculture, the mapper will be able to resolve much smaller fields and make more accurate and reliable distinctions between, for example, corn and soybeans. In other realms it will make finer distinctions between different types of land use or different varieties of rock.

To this end, NASA engineers exploited their experience with Landsat-1, -2, and -3 to optimize the choice of bands. Various combinations would then yield information about the depth of rivers and lakes, indicate the growth stage and vigor of crops, measure the absorption of light by chlorophyll, measure total biomass and stress on a crop, differentiate between snow and clouds, and detect hydrothermally altered rocks and clays. A final band lying in the thermal infrared would measure temperature. Changes between day and night could then be converted into estimates of the heat capacity of a given region and thus into

NASA

Landsat-3 photographs San Francisco Bay

Urban areas around the bay appear as a blue gridwork. Just below, the redwood forests of the Santa Cruz Mountains show up scarlet. In the upper right, the fields of California's central valley are a red-and-pink plaid.

information on subsurface structure.

NASA's engineers still thought of Landsat as an exercise in technology development, however, and so they planned to put the thematic mapper on a simple, one-instrument spacecraft: Landsat-D. The project was announced as a new start in 1977, with a launch projected for 1981. The ever-growing Landsat user community promptly erupted in pent-up rage.

"There was this great hue and cry about 'continuity'," recalls Anthony J. Calio, deputy administrator of the National Oceanic and Atmospheric Administration and until recently a prime mover of the Landsat program as head of NASA's Office of Space and Terrestrial Applications. By this time the market for Landsat products was several million dollars per year. Many of the largest users—including several state governments and such politically potent federal departments as Interior, Agriculture, and Commerce—had begun to make heavy investments in computers, software, and trained personnel. Unfortunately, it was all specialized for the original MSS. None of the software and little of the training would suffice for the thematic mapper, which would have very different characteristics. People were perfectly willing for NASA to develop new technology. But to protect their investment they demanded a less abrupt transition. They wanted NASA to find room on Landsat-D for an old-style MSS.

"The general feeling at NASA was that the MSS wasn't needed," recalls Calio, echoing some of the agency's frustration at the time. "We thought that when people saw the thematic mapper data they wouldn't be interested in the scanner anymore."

But the users' grievances went far beyond continuity. "As we explored new uses for Landsat," says Calio, "it became a requirement by the customer community that they wanted both new data and retrospective data, and they wanted it rapidly. So we were subject to a lot of criticism because we didn't act like an operational agency. People wondered why, when they put a nickle in the slot, they didn't just get a map out. But they forget it wasn't structured for that. These were experimental spacecraft. The way the ground data system developed, the way the whole flow of products was established—it was not geared up to be a production operation cranking out hundreds of scenes per day. It broke down trying to keep up with the throughput."

Out in the field, meanwhile, one heard words like "incompetent" and "insensitive to user needs." One still hears them. A single Landsat scene on computer tape currently costs about $300 from the EROS Data Center (EDC). This is a bargain, most users say, except that delivery of fresh images can take up to 6 months. This delay is intolerable in applications that require timely data, such as agriculture and pollution control. EDC, in turn, blames the delay on slow processing of the incoming data at Goddard.

Another complaint: in the early days at Goddard, before anyone realized that those first images might later be important for looking at long-term changes, the data were stored on tape in analog form instead of digitally. Some of those tapes have seriously deteriorated. "You can't get the data off the tapes," laments one user.

Given the general discontent at the time of the Landsat-D announcement, the federal user agencies were ready to force the continuity issue. In early 1978 an ad hoc council was put together under presidential science adviser Frank Press, and before the year was out the Office of Management and Budget (OMB) had passed the council's recommendation on to NASA in the form of an order: for the sake of continuity, Landsat-D would carry a multispectral scanner.

"OMB did pass the hat among the user agencies to get the money to pay for the scanner," says Calio, "but when the hat came back, it was empty. So that first year, at least, NASA had to eat it all—$6 million or $7 million."

About the same time, stung by criticism of "insensitivity to the users," the agency moved to heal the split. It inaugurated a nationwide program of applications research and technology transfer, which has been quite successful in introducing new users to the system and is still in operation today. And in mid-1979, in an effort to avoid a repeat of the data distribution debacle, the agency restructured its plans for the Landsat-D ground systems. In particular, the MSS is now to function in a high-throughput, operational mode from the beginning. "It's going to crank out up to 200 scenes per day," vows Calio.

NASA

Dallas in Infrared

This multispectral image was taken from an aircraft at 65,000 feet.

The thematic mapper, however, will stay under the engineers' control until January 1985. First they will have to learn to correct its pictures for such things as the motion of the spacecraft, the interaction of the reflected light with the atmosphere, and the jitter of the spacecraft as the scanner and mapper mirrors go banging back and forth. Only then will they study how to boost the data processing to production levels. "A very large segment of this activity is number crunching," explains Calio. "The way you write the software for experimental diagnostics is not the same as for high throughput."

Charles Sheffield

"The technological lead has passed out of the hands of this country."

NASA and its prime contractor, General Electric, wrestled with the ground system all through 1979 and 1980. Meanwhile, Hughes Aircraft was having problems with the mapper. Hughes also built the multispectral scanners in the first three Landsats, but the spectral bands of the mapper were narrower and there were more of them, which meant more detectors had to be crowded into the instrument's focal plane. At each point of each image the mapper was supposed to distinguish between 256 levels of brightness instead of the scanner's 64. Its signal-to-noise ratio was supposed to be higher. It was supposed to return data to earth at 85 million bits per second instead of the scanner's 15 million bits per second. Inexorably, Hughes' original estimate of $40 million for the mapper began to escalate toward $120 million. NASA, faced even then with shrinking budgets and under the gun to get a new MSS flying as soon as possible, began to contemplate the ultimate irony: flying Landsat-D without its thematic mapper.

"Half a dozen times at least, we were on the brink of leaving the thematic mapper off," says Salomonson. "At one time the thrust was to dump the whole thing and build a solid-state device instead."

There are those who think they should have. The device Salomonson refers to is the multilinear array (MLA). If the mapper scans the countryside like a whisk broom, the multilinear array would do it like a push broom. Thousands of tiny silicon detectors (charge-coupled devices) would be lined up perpendicular to the spacecraft's direction of motion; each would scan a continuous line, and together these lines would build up a two-dimensional image with very high resolution. MLA's are available commercially for aerial work. The French National Space Program, for instance, will use an American-built MLA aboard its SPOT satellite, a commercial remote sensing spacecraft that it plans to launch in 1984. This makes some people frantic.

"The technological lead has passed out of the hands of this country," declares Charles Sheffield of Earthsat Corporation, a Maryland firm specializing in the analysis of Landsat data. "The thematic mapper reaches 30-meter resolution, but you can't push the scanner technology much further. If we ever do transfer Landsat to the private sector, they will be taking over obsolete technology. The multiple linear array is the logical next step. But the U.S. isn't developing it—at least not for civilian use."

True enough, there is no plan (and no money) to fly an MLA on a satellite, say NASA planners. Under the Reagan Administration that will be left to private industry. "But unequivocally, our MLA development program is one of the finest and most advanced in the world," says James C. Welch, technical director of NASA's Earth and Planetary Exploration Division. The problem with flying it on Landsat-D, he maintains, was that the silicon detectors in the MLA need a lot of work before they can operate in the far infrared, the region the thematic mapper will explore. "We could have done what the French are doing," he says, "but there would have been no advantage over Landsats 1, 2, and 3. The thematic mapper is miles ahead."

Anthony J. Calio

"These were experimental spacecraft."

Thus, NASA stayed with the thematic mapper. Fortunately, Hughes was able finally to get its problems under control. The projected launch date was slipped to 1982, and by late 1980 the thematic mapper was solidly back on board.

Landsat-D is currently undergoing final checkout at the General Electric Space Divison plant in Pennsylvania. A Delta 3920 launch vehicle awaits the satellite at Vandenberg Air Force Base in California. In July, if all goes well, the boxy, awkward-looking satellite will take its station in polar orbit some 700 kilometers above the surface and in smooth, efficient streams the data will begin to flow out to the users. With its MSS and eventually its thematic mapper set up for high-volume production, Landsat-D could go a long way toward ending a decade of tension and recrimination.

Unfortunately, the deeper controversy will not end there. Rhetoric aside, the problems of the last decade were not really NASA's fault. Congress created NASA to be a research and development agency, and with Landsat it fulfilled that role very well. NASA is not supposed to be an operational agency, so not surprisingly it did not act like one.

More important, however, the National Aeronautics and Space Act of 1958 has a fundamental omission: it does not tell NASA what to do when a given space technology becomes mature. Arguably, the Landsat system could have been made operational years ago. But then who would run it? The decision was not NASA's to make; it was, and is, the responsibility of Congress and the White House.—M. MITCHELL WALDROP

Imaging the Earth (II): The Politics of Landsat

Landsat has outgrown NASA; it is going to have to move out, but where?

As the National Aeronautics and Space Administration's Landsat program enters its second decade, the government is searching frantically for some public or private entity that will run the satellites as a continuous service. It has become a high-stakes game, played at a very high level. Unfortunately, no one seems sure of the rules.

The first three Landsats, peering down at the earth with sensors atuned to both visible and infrared wavelengths, have sent home images that are widely used in such applications as crop surveys, land-use planning, pollution monitoring, and mineral and oil exploration. The thematic mapper, a second-generation sensor due for launch this July aboard NASA's Landsat-D spacecraft, promises to be even more fruitful. In principle, the technology is already there for private firms to operate remote sensing satellites for a profit. But there are a number of fundamental problems in the way.

For one thing, NASA was created in the post-Sputnik frenzy of 1958, when space was the ultimate challenge to science and engineering. It hardly seemed possible that space operations could ever become routine. So NASA was established purely as a research and development agency. Not only does it have no mandate to manage operational systems, but when various space technologies do mature, as communications and weather satellites did in the mid-1960's, the National Aeronautics and Space Act gives no guidelines on how to make them operational. Decisions have been made ad hoc: weather satellites, for example, were passed to another government agency, the Commerce Department's National Oceanic and Atmospheric Administration (NOAA); communications satellites were given to Comsat, a quasi-private firm chartered by the federal government. Until somebody makes the same kind of decision for Landsat, it will stay in limbo.

A second and thornier problem is that Landsat, unlike the weather or communications satellites, has no natural home. The market is inchoate and fragmented. Individual users may be enthusiastic, but they are scattered through hundreds of federal agencies, state agencies, universities, and private industries. There is no one entity that caters to all these interests. Worse, Landsat imagery serves both the public welfare (as in pollution monitoring and land use planning) and private profit (as in mining and oil exploration). People cannot even agree on whether Landsat should be operated by the public sector or the private sector.

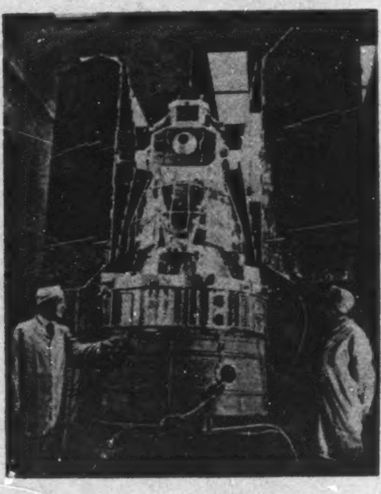
Consider the fate of rival bills introduced in the late 1970's by Senators Harrison Schmitt (R–N.M.) and Adlai Stevenson III (D–Ill.). Schmitt called for turning the satellites over to a private corporation along the lines of Comsat. Stevenson envisioned a remote sensing service set up within NASA. Both efforts foundered on the same rock: an operational Landsat, according to administration witnesses, was "premature." It needed more study. Cynics suggest that this was just an effort to put off making a decision. As long as Landsat stayed in NASA, nobody would have to take the flack for putting it somewhere else.

Finally, the front-end costs of an operational remote sensing program are daunting. NOAA has estimated that such a program, including the satellites, launch vehicles, and ground systems, would cost anywhere from $1 billion to $10 billion over 10 years. Yet the market for Landsat products is still relatively small; NOAA estimates $6 million per year. Ironically, many potential users may be hanging back from putting money into computers and Landsat-oriented software until they can be sure of a continuous flow of Landsat data—that is, until the program becomes operational. Given this state of affairs, it's hard to see how any private firm is going to touch it without some form of government subsidy to get things going.

The one thing that everybody does agree on is that Landsat is doing something uniquely valuable and worthwhile. Handled correctly, orbital remote sensing could become an important new industry for the United States, perhaps even a significant element in foreign trade. But handled as it has been, the chance could slip away. The United States is running out of time on Landsat.

"The curious thing about the U.S. program is the refusal to admit that the rest of the world exists," warns Charles Sheffield, vice president of the Earth Satellite Corporation, a Maryland firm specializing in the interpretation of Landsat imagery for private clients. "Commercialization of space remote sensing will happen in this decade," says Samuel W. McCandless, former project manager for NASA's Seasat program and now a private consultant on remote sensing. "But it may not occur in this country."

Europe apparently has no qualms



NASA

Landsat-1 undergoes checkout in 1972

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about the commercial viability of space. The European Space Agency is vigorously promoting its Ariane launcher as an alternative to the space shuttle. And in 1978 the French announced that they were buying into the commercial remote sensing market with a satellite called SPOT, due in 1984. The Japanese, meanwhile, are not far behind. If the United States keeps dithering with Landsat, say Sheffield, McCandless, and innumerable other critics, customers are going to turn elsewhere.

In November 1979, President Jimmy Carter tried to untangle the Landsat situation with Presidential Directive 54, which incorporated the recommendations of his space policy review panel. NOAA, he said, would take over temporary stewardship of the Landsat system in 1983 and operate it along with the agency's existing weather satellites, while charging enough to recover its costs. Once NASA finished proving out the second-generation thematic mapper on its new Landsat-D satellite, that, too, would be turned over. (NASA, of course, would continue its development of still newer technologies.) Meanwhile, NOAA was to work out a plan for the timely transfer of remote sensing technology to the private sector.

Implicit in all this was a commitment by the federal government to provide data continuity until the private sector could take over. Landsat-D′, a backup and successor to Landsat-D, was already under construction. At NOAA's suggestion, Carter included funds for two more spacecraft—Landsat-D″ and Landsat-D‴—in his valedictory budget request in January 1981. Together, these four spacecraft were to provide continuous coverage into the 1990's.

Then came Ronald Reagan and the great budget cuts of March 1981. Landsats-D″ and -D‴ went on the chopping block immediately; budget director David Stockman was philosophically opposed to any kind of "operational" activity by the government. Once Landsat-D dies in 1985 and D′ in 1987, says the OMB, that will be the end. Thereafter, by definition, the Landsat program will be in the hands of the private sector.

This is a deadline in the literal sense, and the prospect makes most observers shudder. "It's pretty well accepted as gospel in Washington and industry that the market for Landsat data today is totally inadequate for private sector investment, if that means building, launching and operating the satellites," says Wilbur Eskite, policy analyst for NOAA.

Or, as Sheffield puts it: "The Administration can't shift Landsat to private industry if private industry doesn't want to accept it." Commercilization is a wise way to go, he adds—but not all at once. "Why not have NASA keep on with providing the data stream, and have private industry get busy distributing and interpreting it?" Data dissemination, now done through the U.S. Geological Survey's EROS Data Center in Sioux Falls, South Dakota, could be commercialized right away. Later, as the market expands, the responsibility for operating the system could be handed over. Only when the market grows very large would the private sector start to develop and launch the satellites themselves.

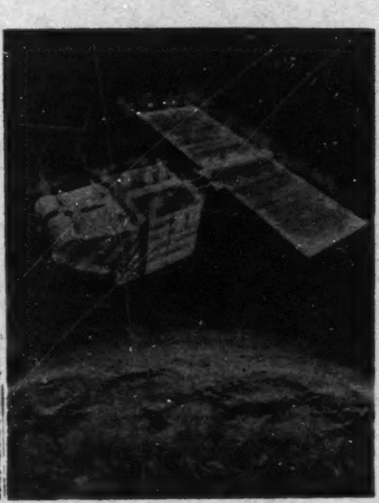
This kind of phased commercialization has been widely endorsed within both NASA and the user community, and is essentially what the Carter Administration had in mind. Another possible approach is that of Comsat, which has recently offered to take over both Landsat and NOAA's weather satellites lock, stock, and launch vehicle—if the government guarantees the company some hefty amount of remote sensing business per year. (Washington spends a good deal on weather and remote sensing already. Comsat likes to compare the guarantee to the government's introduction of airmail in the 1930's, which was basically an effort to provide security for the fledgling airline industry.)

By last fall, the Reagan Administration had begun to perceive that the commercialization of Landsat might require a little more than simple government withdrawal. The Carter directive 54 is technically still in effect, but now the question has been handed off to yet another study committee, in this case the Cabinet Council on Commerce and Trade, chaired by Commerce Secretary Malcolm Baldrige. The council looked over the issues at its December 1981 meeting, requested more information, and is currently trying to decide what it is that it wants to decide. Sheffield quotes Parkinson: "Delay is the deadliest form of denial."

Sooner or later, of course, the issue will be settled—either deliberately or by default. But was all the delay and acrimony really necessary? Is there a better way? Perhaps, as many have suggested, Congress should just expand NASA's charter to include routine operation of space systems, similar to what is now done by Comsat or NOAA. At a minimum, some clear, consistent, and stable policy on commercialization is needed from the presidential level (and not just for NASA's sake; the problem of technology transfer is government-wide). On the other hand, the elections of 1980 demonstrate just how gusty the winds of policy can be.

But one can hope that NASA and the current Administration will draw some useful lessons from the Landsat agony. NASA is already beginning to grapple with how to commercialize or otherwise "operationalize" the space shuttle itself. In a few more years it may be doing the same with a permanent space operations center, and perhaps space manufacturing technology. The decisions are not going to get any easier.

—M. Mitchell Waldrop



SPOT.

The French spacecraft, due for launch in 1984, will be the first commercial remote sensing satellite.

Centre National d'Études Spatiales

What Price Privatizing Landsat?

Reagan's free market science policy could soon produce a land and weather satellite monopoly—on COMSAT's terms

In the name of free enterprise, the Reagan Administration has spent 2 years figuring out how to transfer the government's land remote sensing satellites (Landsats) to the private sector. Ironically, it may soon find itself setting up something that looks a lot like a government-subsidized Landsat monopoly. The federal system of weather satellites may be thrown in too, with the government buying back the weather data for more than it spends now.

According to a plan recently adopted by the Cabinet Council on Commerce and Trade, and now awaiting President Reagan's approval, the Communications Satellite Corporation (COMSAT) is likely to take over Landsat and weather satellite operations with the government providing a guaranteed market for land and weather data for 15 years. This arrangement would essentially subsidize commercial operations through government purchases. How an administration that loathes subsidies on principle came up with such a plan is a story worth recounting: it offers a classic study in the collision of ideology with reality.

Landsat's commercial potential has been clear from the beginning. The National Aeronautics and Space Administration (NASA) launched Landsat 1 in 1972 (*Science*, 26 March 1982, p. 1600) and followed it with Landsat 2 in 1975 and Landsat 3 in 1978. The satellites' sensors imaged the earth both in visible light and at infrared wavelengths, producing false-color images of scarlet forests, red patchwork farms, blue city grids, and brown crinkled mountains. Agronomists were able to quickly inventory crops over vast areas and monitor the course of diseases such as corn leaf blight. Geologists could take in whole fault zones at a glance, as they pinpointed possible new mineral deposits or oil fields. Land-use planners could monitor urban sprawl and strip-mine damage on a regional basis.

Economists have estimated that the ultimate economic value of land remote sensing to the United States could approach $10 billion per year, and virtually everyone has agreed that Landsat should eventually be transferred to the private sector. Unfortunately, NASA, Congress, and the community of Landsat users have spent the last decade arguing about how to accomplish the transfer (*Science*, 2 April 1982, p. 40).

In 1979, President Jimmy Carter tried to cut through the fog by presidential directive. On 31 January 1983, he said, NASA would hand over Landsat operations to the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), which would also be responsible for working out a long-term commercialization plan. Meanwhile, to soothe users' fears of an interruption in the data flow, NASA would guarantee continuity into the 1990's by launching a series of four advanced satellites known as Landsat D, D′, D″, and D‴.

Landsat 4 in orbit

Too many bells and whistles?

NOAA took charge of Landsat operations last month, on schedule. But little else in Carter's plan has survived, because in 1981 the Reagan Administration abruptly changed the ground rules.

In its first budget-slashing exercise in February 1981, the White House Office of Management and Budget (OMB) decreed that the federal involvement in Landsat would end with the launch and eventual demise of D′—and it would go that far only because D and D′ were already in production. (Landsat D was launched in July 1982; D′ is planned for launch in 1985 and is expected to last through 1988.) Ten years of demonstration was enough, said OMB. If the market was adequate, the private sector would move in and start building its own satellites. If not, why should the government continue to do so? Indeed, the government should sell both Landsat D and D′ to a private operator as soon as they were launched.

The laissez faire logic was impeccable. Unfortunately, as many people in the remote sensing community have pointed out, it had little to do with the real world.

First, while the market potential may be huge, 10 years of demonstration has *not* been enough. NASA designed and operated the Landsats as an experimental system. Practical applications were peripheral to proving out the technology. One can fault NASA for this attitude—and many people have, loudly—but the fact remains that the government has done relatively little to promote remote sensing, or to tailor the product to the market. Moreover, many potential users have shied away because Landsat applications require a considerable investment in computers, software, and personnel, with no guarantee that the government or anyone else will continue to provide the data. Thus, Landsat enthusiasts remain widely scattered in government agencies, private corporations, and universities. The market as a whole is still small, immature, and fragmented.

Second, even in a vigorous market it is not clear that anyone would want to buy the NASA satellites. As experimental spacecraft they are complex and expensive. So are their ground stations. Landsat D (known as Landsat 4 now that it is in orbit) will cost a total of $300 million. It is producing scenes of unprecedented richness and detail—but only a few per day. A private vendor would prefer to operate a simpler, cheaper set of spacecraft based on proven technology, and put out hundreds of scenes per day. "Why should we pay for a lot of bells and whistles we don't want?" asks one corporate specialist.

Third, given the first two realities, no private operator is going to touch the land remote sensing business without some form of subsidy. The situation is just the inverse of what happened in the communications satellite boom of the 1960's: the communications market was already fully developed (everybody had a telephone) and there was no satellite system in place (the operators could build what they wanted). For Landsat, however, many in the remote sensing community favor some form of "phased" commercialization. The existing system breaks naturally into pieces, they point out: the satellites, built and launched by NASA; the ground stations, now operated by NOAA; data archiving and distribution at the Department of the Interior's EROS Data Center in Sioux Falls, South Dakota; and a "value added" industry comprised of entrepreneurs who analyze and interpret the scenes for paying customers. The far end is commercial already. The idea is thus to work back up the chain, spinning off the less expensive and risky pieces as the market develops and leaving the big ticket items—the satellites—with the government until the market is fully mature.

Finally, by truncating the Landsat D series, the OMB might well have truncated the whole industry. It takes years to build a satellite, users warn, and if somebody does not start cutting hardware soon, there will be nothing to replace Landsat D' after 1988. They point to the French, who plan to launch a commercial remote sensing satellite known as SPOT in 1984, backed by a government that has no qualms about subsidies. They point to the Japanese, who have announced similar plans. "If we fail to provide the data, France and Japan will step in to fill the gap," says Michel T. Halbouty, a Houston entrepreneur who uses Landsat data for oil and gas exploration, and who recently headed a major Landsat study committee for the Commerce Department. Among the users, at least, the situation has become urgent to the point of crisis: the United States is on the verge of abandoning yet another industry to foreign competition.

All this was pointed out at length in 1981. Yet the OMB remained adamant: no government support after Landsat D'.

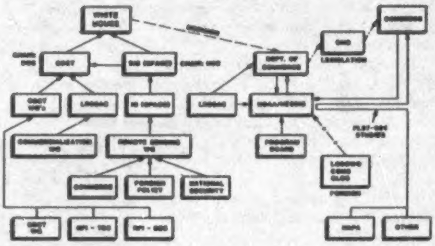
Little of the users' urgency seemed to penetrate the White House. The details of the transition clearly needed a lot of thought, and the voluminous studies that led up to Carter's 1979 plan had been . . . well, Carter's. So the question was handed off to the Cabinet Council on Commerce and Trade, headed by Commerce Secretary Malcolm Baldrige, and from there to a sublabyrinth of working groups and advisory committees.

Meanwhile, COMSAT was quietly making OMB an offer. COMSAT had been enthused about land remote sensing for some time, and had tried hard, without success, to get the Carter Administration to set up a phased commercial system. But now the mind-set of the new Administration was clear. So COMSAT proposed the following: the company would take on Landsat, build new satellites, and nurse the market for however long it took—exactly what OMB wanted—*if* the government would also sell COMSAT its weather satellites and guarantee that every year for 15 years it would make some hefty minimum purchase of land and weather data.

The *weather* satellites? No one in Washington had ever contemplated commercializing the weather satellites. Why bother? Who would buy the data, other than NOAA and the Department of Defense (DOD)?

Still, to hear COMSAT tell it, the plan was quintessential Reaganomics. Through the virility of the private sector, COMSAT would achieve substantial savings by consolidating and modernizing the two systems and by more efficient operation. In fact, the deal might actually save the government money—as much as $1 billion over 10 years. True, the guaranteed purchase of land and (especially) weather data would be used to cover the initial losses on Landsat. But it would not really be a subsidy. The government spends a lot for Landsat and weather data anyway and, as COMSAT was fond of pointing out, there was a precedent: in the 1930's the government had introduced air mail, in large part to provide security and cash for a fledgling airline industry.

A simple guide to Landsat advisory committees



Now most observers agree that, from a technical standpoint, COMSAT's plan has a lot to recommend it. There are real advantages to combining and streamlining the two systems, especially since COMSAT also hopes to incorporate a series of ocean sensing satellites, which no one is working on right now. Moreover, having control of the whole system would allow COMSAT (or any other operator) to tailor new satellites to the needs of the market. All of this would indeed be more difficult in a phased commercialization where the government retained the satellites.

On the other hand, COMSAT's cost estimates have been highly controversial. For one thing, the billion dollar savings figure assumes that the government would otherwise continue a land remote sensing program after Landsat D', when in fact OMB has explicitly ruled that out. Then there are uncertainties over how to compare different accounting practices and how to figure out what the government actually does pay for remote sensing.

But in 1981, all this was really beside the point. The OMB liked any idea that enhanced the private sector, especially if it could also be construed as slimming the budget. Commerce Secretary Baldrige and his deputies liked the idea for less ideological reasons: if the weather system was COMSAT's price for taking over Landsat, then COMSAT should have it.

Thus, the commercialization of the weather satellites became a major issue for the Cabinet Council and its multitudinous advisory groups. The deliberations continued.

In due course—November 1982—the deliberations came to an end and all the reports and findings landed back on Baldrige's doorstep. Unfortunately for the vision of subsidy-free transfer, however, they all said pretty much the same thing:

- There is no market that can fully support the Landsat system in its present form; furthermore, the development of a self-sustaining market for land remote sensing will take a decade or more.
- There is no conceivable savings on the weather satellites (by common operation, for example) that could offset the losses on Landsat; neither is there an untapped, nonfederal market for weather data that could offset the losses.
- There is no way that a private opera-

tor can afford to do an adequate job on advanced remote sensing research and development; NASA and DOD must both maintain a vigorous effort.

There is, in other words, no magic way out. After 2 years of study the Administration still had the same choices it had in the beginning: subsidize the land remote sensing industry for a decade or watch it crumble to foreign competition. COMSAT's plan for a guaranteed purchase of weather data would at best be a cross-subsidy. In fact, many advisors—particularly the industry representatives who constituted the Land Remote Sensing Satellite Advisory Committee under Houston's Michel Halbouty—were still calling for some form of phased commercialization, with government providing continuity of data beyond Landsat D'.

However, the Commerce Secretary's staff did not quite see things that way. By the time they had distilled the reports into a concise set of recommendations, the idea of phased commercialization had vanished. As approved in a closed session by the Cabinet Council on 15 December 1982, the recommendations call for competitive bids to be solicited for the land and the weather systems separately. Interested parties would be allowed to submit a joint bid on both, of course.

To cynics this was a clear setup for COMSAT. And, in truth, COMSAT does seem the only realistic candidate to win the bids. No one else has demonstrated the slightest interest in the weather satellites, or in taking over all of Landsat. The company is very well connected in Washington. And Baldrige and his deputies have been the capital's most enthusiastic supporters of the weather transfer.

On the other hand, the people at Commerce maintain that their opposition to phased commercialization was not a favor to COMSAT. Rather, they saw it as a source of endless turf battles and foot dragging. Every time they tried to spin off another piece of the system, they explained, the bureaucracy would fight to keep it. Best to get the government out quickly.

(Ironically, many working-level bureaucrats in the satellite services want to get the government out too but for different reasons: the COMSAT proposal may be the last best hope of sheltering Landsat from the OMB. "This administration shows no capability of sustaining operations," says one weary veteran. "It's the worst I've ever seen it: the OMB endlessly tweaks the operations and changes the budget, just because we're under their control. We don't know what we've got from one month to the next. Get [the land and weather satellites] out in the world, get them free of these biennial shifts. At least that would keep the data coming in.")

What happens now is not clear. The Cabinet Council's recommendations—which have not yet been made public—went to the White House in January for final approval by the President. At this writing there is still no indication of whether that approval will be forthcoming, or when. The OMB is now dragging its feet, since the council was honest enough to admit that "establishing a private entity and assuring the U.S. of a competitive entry in international civil space remote sensing will require an enhanced budget commitment [in fiscal 1984]"—that is, a subsidy and a big infusion of research and development funds.

On Capitol Hill, meanwhile, eyebrows have been raised at how quickly and quietly the decisions have been made since November. "Greased" is one staffer's word for it. Could it be that no one in the Administration wants Congress' advice on the subject?

The two senators who were most interested in land remote sensing, Senators Harrison H. Schmitt (R–N.M.) and Howard W. Cannon (D–Nev.), were both defeated last year. But others, such as Representatives James H. Scheuer (D–N.Y.) and Raymond J. McGrath (R–N.Y.) have begun to express concern and may well call hearings on the matter. Some key questions:

- Will the Cabinet Council plan lead to the creation of a government-subsidized monopoly? American Science and Technology (AS&T), for example, a small new company in Bethesda, Maryland, is gambling that the remote sensing market is already mature enough to support an inexpensive, proven-technology system. It will attempt to fill the post–Landsat D' gap with its own, privately financed satellites—which would be launched on the privately financed Conestoga rocket of Space Services, Incorporated. Prospects for venture capital look good, claims company spokeswoman Diana Josephson. But money could dry up fast if AS&T had to face a large, heavily subsidized competitor such as COMSAT.

It would be ironic indeed if the Administration's plan to promote the private sector were to end up stifling genuine entrepreneurs. One would also have the spectacle of NASA doing advanced research for the benefit of a single corporation.

- How much will it cost? The detailed cost estimates on COMSAT's land/weather proposal will remain proprietary until the company submits a bid. Then the arguments can begin in earnest over how much the government will really have to pay. (The purchase guarantee could not be absolute, by the way, since Congress has to approve the budget every year.) "If it is a subsidy," says one Hill staffer, "why not just call it that?" A related issue is whether the President's fiscal 1984 budget actually contains enough funding to cover the cost, or even the research and development that everyone is asking for.

- Should the weather satellites be commercialized? This idea seems to scare people, giving them visions of coastal cities that cannot afford hurricane warnings, and the like. In fact, COMSAT would be selling its data directly to NOAA, so everyone would hear their weather reports as usual on the morning radio. A more serious concern is the fact that NOAA's weather satellites are a prime source of weather data for the DOD. (The DOD is supposed to have its own satellites, but it is rumored that in one recent year, they were all inoperable. NOAA was providing everything.) It is unlikely that DOD would get overly nervous about relying on a commercial weather system—it now routes about 80 percent of its communications traffic through COMSAT satellites—but the contract would nonetheless have to preserve DOD's right to commandeer the weather system in case of emergency.

Finally, before people go carping too much at COMSAT, they might want to recall who precipitated the whole episode. First, Reagan's OMB struck down the Carter plan, truncated the Landsat D series, and threw the system into crisis for reasons of ideology and budget. Then, with foreign competition already coming on strong, it spent two fruitless years in quest of a magic way to commercialize Landsat without subsidies. In the process it caused reams of studies to be generated on an issue that had already been studied ad nauseum.

Meanwhile, work on the successor to Landsat D' should have started last summer. It must start this summer if the program is to have continuity. Congress and the Administration may now be forced to accept the Cabinet Council plan as the only way to get someone moving in time. If they reject it and send the issue back for still more studies and reports, then maybe a new and struggling venture such as AS&T can fill the gap. Maybe. But it is certain that the French will be launching their competitor, SPOT, in 1984.—M. MITCHELL WALDROP

COMSAT'S FIRST DECADE: DIFFICULTIES IN INTERPRETING THE COMMUNICATIONS SATELLITE ACT OF 1962

I. Introduction

The enactment of the Communications Satellite Act of 1962[1] (hereinafter referred to as the Act) marked the beginning of a new era in the field of communications for the United States. President Kennedy and the Congress felt an urgent need to stimulate all available talent and resources toward the development of a global communications satellite system, while maintaining private competition in the procurement of equipment and the providing of services to the public. The result was the creation of Comsat, a private[2] communications corporation intended to be a unique experiment in public and private ownership under close supervision by the federal government.

Comsat's goal is to provide a global communications satellite system "which will be responsive to public needs and national objectives, which will serve the communication needs of the United States and other countries, and which will contribute to world peace and understanding."[3] From the Act's inception, it was recognized that foreign cooperation would be essential if the global dimensions envisioned by the Act were to be achieved;[4] however, due to conflicts inherent within the structure of Comsat, both the development of the satellite system and the United States' dealings with the rest of the world were handicapped. This Note will trace the development of this global satellite system, pointing out the inherent conflicts within Comsat and indicating the effect they had on the accomplishment of the goals set out in the Act.[5]

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[1] 47 U.S.C. §§ 701-44 (1970).

[2] *Id.* § 701(c). Although the Act specifically refers to the corporation as "private," there is controversy surrounding a definition of the exact nature of the entity. One view suggests that the character of the corporation is that of a joint venture between the federal government and private industry. Levin, *Organization and Control of Communications Satellites*, 113 U. Pa. L. Rev. 315, 324-25 (1964-1965). [hereinafter cited as Levin]. Another commentator prefers to describe the corporation as quasi-public. Scrader, *The Communications Satellite Corporation: A New Experiment in Government and Business*, 53 Ky. L.J. 732, 736 (1964-1965) [hereinafter cited as Schrader]. Yet another view, with the benefit of several years of operational perspective, suggests that "Comsat clearly evolved further toward becoming a purely private company than its creators intended." M. Kinsley, Outer Space and Inner Sanctums 195 (1976) [hereinafter cited as Kinsley].

[3] Act, 47 U.S.C. § 701(a) (1970).

[4] M. Schwartz & J. Goldsen, Foreign Participation in Communications Satellite Act of 1962 4 (Rand Memo No. 3484-RC, Feb. 1963) [hereinafter cited as Rand Memo].

[5] Among the Act's enumerated goals are: (1) the rapid development of a commercial global communications satellite system, (2) the extension of such services to economically less developed areas as well as well-developed areas, (3) efficient and economical use of the electromagnetic frequency spectrum, (4) reflection of the benefits of this system in both quality of services and charges for such services, (5) nondiscriminatory access to the system

Source: Georgia Journal of International and Comparative Law, v. 7, 1977, pp. 678-692.

II. BACKGROUND

A. *The Organization of Comsat*

Congress engaged in extensive debate regarding the advantages of private versus public ownership before the structure of Comsat was finalized.[6] Formerly, in 1960, it had appeared as if American Telephone and Telegraph Corporation (AT&T) would itself develop and control the satellite system.[7] In order to avoid the appearance of monopolization of the industry, AT&T joined with Western Union International Corporation, International Telephone and Telegraph, and RCA to propose to the Congress an exclusive consortium directed toward the development of space satellite communications.[8] President Kennedy countered with a plan providing for complete private ownership but limiting the interest of any individual or corporation to a maximum of 15-20 percent.[9] Numerous proposals were submitted by both private and governmental sectors, ranging from complete government ownership to total control by existing private international communication carriers.[10] Congress felt the need to strike a compromise, due to an impending threat of Soviet leadership in space communications and also in order to enhance the poor legislative record of the 78th Congress.[11] The result was the creation of a quasi-public entity,[12] with half its ownership available to the international common carriers and the other half open to the public.[13]

Although the concept of total government ownership of the satellite system was given little support, much could be said in its favor. A government owned arrangement could insure access by all interested parties

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by all authorized users, (6) the maintenance of maximum competition among private industry in the provision of equipment and services utilized by the system, (7) the continuation of competition in the provision of communications services to the public, and (8) adherence to Federal antitrust laws. The Congress did not intend to preclude the use of the communications satellite system for domestic communication services where consistent with the Act's provisions, nor to preclude the development of additional communications satellite systems, if required. 47 U.S.C. §§ 701(a)-(d) (1970).

[6] *See generally Hearings on Antitrust Problems of the Space Satellite Communications System Before the Antitrust and Monopoly Subcomm. of the Senate Comm. on the Judiciary*, 87th Cong., 2d Sess. (1962); *Hearings on Communications Satellites Before the House Comm. on Science and Astronautics*, 87th Cong., 1st Sess. (1961).

[7] D. Smith, Communications Via Satellite 74 (1976) [hereinafter cited as Smith].

[8] Kinsley, *supra* note 2, at 4.

[9] *Id.* at 5.

[10] For a general discussion of the debate concerning the creation of Comsat, see Smith, *supra* note 7, at 93-108.

[11] J. Galloway, The Politics and Technology of Satellite Communications 71 (1972) [hereinafter cited as Galloway].

[12] 47 U.S.C. §§ 731-35 (1970).

[13] "The passage of the Act culminated a process which had been characterized by bargaining and compromise but also by polemics and ideological involvement." Galloway, *supra* note 11, at 69.

without discrimination. Moreover, such an arrangement would go towards the elimination of possible conflicts of interest resulting from private ownership of both ground stations and the system itself.[14] "Such ownership promised maximum coordination of civilian and military space programs and an end to reliance on ineffective regulation under conditions of natural monopoly."[15] The proponents of government ownership mounted a four pronged attack against private ownership: (1) conflict with antitrust laws could occur since the major carriers were also the largest equipment suppliers, (2) an early transfer of satellite operations to the private sector could result in a mediocre system, (3) since government funds developed the satellite technology, the benefits belonged to the public taxpayers, and (4) due to the corporation's direct dealings with foreign governments it would be placed in a position to establish foreign policy.[16] The passage of time did not allay the fears of those advocating government ownership.

B. *Internal Structure of Comsat*

The corporation created by the Communications Satellite Act of 1962 has been termed "quasi-public" due to "the various . . . controls . . . plus the presidential appointment of directors and obvious future interrelationship with other federal [*sic*] agencies . . . ."[17] Both internal and external controls were established in an effort to protect the public interest. Internal controls consisted of a broad base of ownership and the placement of government representatives on the board of directors.[18] Section 734 deals with the financing of the corporation and allows authorized communications common carriers to own up to 50 percent of the stock. Section 733 stipulates that the board of directors consist of 15 members: six chosen by the international carriers, six elected by the other stockholders, and the remaining three appointed by the President with the consent of the Senate.[19] It was hoped that under such an arrangement, ultimate control of the corporation would be exercised by those possessing superior managerial ability rather than political influence.[20] As it turned out, the presidential appointees have been prominent private citizens easily susceptible to manipulation, and with little experience in communications.[21]

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[14] Levin, *supra* note 2, at 334.

[15] *Id.* During Senate hearings, it was claimed that:

> Not only does the committee bill create a private monopoly, it would go even further and bestow on that single private monopoly the benefits of billions of dollars of the taxpayers' money. This legislation, if enacted, likely would constitute the biggest giveaway in the history of the United States.

S. REP. No. 1584, 87th Cong., 2d Sess. 51, *reprinted in* [1962] U.S. CODE CONG. & AD. NEWS 2269, 2309 (minority views). The report continued:

> Thus, in the interest of fostering competition and innovation in the communications satellite field, separate ownership of international communications carriers and the communications satellite system is not only advisable but essential. Private ownership and control of the space satellites would carry with it a built-in conflict of interest that would inevitably tend to slow down the most rapid development and maximum utilization of the best possible satellite system.

S. REP. No. 1584 at 52, [1962] U.S. CODE CONG. & AD. NEWS 2310-11.

[16] SMITH, *supra* note 7, at 106-07.

[17] Schrader, *supra* note 2, at 736.

[18] SMITH, *supra* note 7, at 108.

External control is manifested in several provisions of the Act, one of which prescribes seven functions that the President[22] directs to insure that the corporation operates according to the objectives of the United States in establishing a global communications satellite system which will contribute to "world peace and understanding."[23] The National Aeronautics and Space Administration (NASA) serves as technical consultant and furnishes launch facilities on a reimbursable basis.[24] The Federal Communications Commission (FCC) is given extensive regulatory power over the activities of the corporation.[25] Additionally, upon entering into business negotiations with any international or foreign entity with respect to facilities, operations, or services, Comsat is required to notify the State Department of such negotiations.[26] The State Department then advises the corporation of relevant foreign policy considerations.[27] This elaborate system of checks and balances seems to have provided no obstacle with respect to the objectives of the major common carriers. An examination of the early years of Comsat's development demonstrates that the major carriers had little difficulty in attaining favorable rulings in areas where their other non-satellite private investments were at stake.[28]

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[19] Under the provisions of the original Act, the international carriers were allowed to choose six directors regardless of the percentage of stock they owned. Section 733 was amended in 1969, establishing a proportional system whereby the number of directors elected by the communications carriers is directly proportional to the percentage of carrier-owned stock. 47 U.S.C. § 733 (1962), *as amended* Pub. L. No. 91-3, 83 Stat. 4, 47 U.S.C. § 733 (1970).

[20] Schrader, *supra* note 2, at 734.

[21] Kinsley, *supra* note 2, at 205-11. Kinsley points out that the presidential directors were ineffective due to their lack of expertise. *Id.* at 208. "Both the practicalities of life and the lessons of history lead to the conclusion that the appointment of government directors to a private board cannot effectively protect the public interest against private abuse." Schwartz, *Governmentally Appointed Directors in a Private Corporation - The Communications Satellite Act of 1962*, 79 Harv. L. Rev. 350, 363 (1965-1966).

[22] 47 U.S.C. § 721(a) (1970). Specifically, the President shall:

> (1) aid in the planning and development and foster the execution of a national program for the establishment and operation, as expeditiously as possible, of a commercial communications satellite system;
>
> (2) provide for continuous review of all phases of the development and operation of such a system, including the activities of a communications satellite corporation authorized under subchapter III of this chapter;
>
> (3) coordinate the activities of governmental agencies with responsibilities in the field of telecommunication, so as to insure that there is full and effective compliance at all times with the policies set forth in this chapter;
>
> (4) exercise such supervision over relationships of the corporation with foreign governments or entities or with international bodies as may be appropriate to assure that such relationships shall be consistent with the national interest and foreign policy of the United States;
>
> (5) insure that timely arrangements are made under which there can be foreign participation in the establishment and use of a communications satellite system;
>
> (6) take all necessary steps to insure the availability and appropriate utilization of the communications satellite system for general governmental purposes except where a separate communications satellite system is required to meet unique governmental needs, or is otherwise required in the national interest; and
>
> (7) so exercise his authority as to help attain coordinated and efficient use of the electromagnetic spectrum and the technical compatibility of the system with existing communications facilities both in the United States and abroad.

[23] *Id.* § 701(a).

[24] *Id.* § 721(b).

III. CONFLICTS IN DEVELOPMENT

A great deal of concern was voiced over the sufficiency of the incentive given the international common carriers to develop a communications satellite system in direct competition with their existing cable facilities.[29] Proponents of the bill thought that close government supervision would guard against any hesitancy by the carriers to pursue a truly effective satellite system.[30] In actuality, the statutory monopoly created by the bill encouraged close cooperation among the participating carriers.[31] The following FCC decisions, dealing with ambiguities in the Act, illustrate just how successful the carriers were in obtaining favorable rulings.

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[25] *Id.* § 721(c). The Commission's ability to perform its regulatory functions will be discussed later in this Note.

[26] *Id.* § 742. Amendments to the original Administration bill drastically limited the role of the State Department.

[27] *Id.*

[28] A prime illustration is AT&T's continued insistence upon expanding its cable facilities despite the proven economy and efficiency of satellites. When satellite circuits first became available over the North Atlantic, AT&T agreed to use them until the route was served by approximately equal members of satellite and cable circuits. Following years of legal maneuvering, this 50-50 policy became the FCC's reasonable parity guideline. As a result, the enormous proliferation of satellite circuits has supported the carriers' arguments for new cables to maintain this reasonable parity, rather than reduce their need, which would be the logical conclusion. The FCC's TAT-5 cable decision is a perfect case where AT&T urged the need for a new cable solely on the basis of balance. *See* Applications for Authorization to Participate in the Construction and Operation of an Integrated Submarine Cable and Radio System Between the U.S. Mainland and Spain, Portugal, and Italy, 13 F.C.C. 2d 235 (May 22, 1968).

[29] "Congress . . . feared that common carriers with substantial investments in existing undersea cable and high frequency radio facilities would attempt to protect their investments by retarding new developments which threatened them with obsolescence." Note, *The Communications Satellite Corporation: Toward a Workable Telecommunications Policy*, 27 HASTINGS L.J. 721, 733 (1975-1976) [hereinafter cited as HASTINGS NOTE].

[30] "Its proponents also hoped that it would provide greater inducements to economic efficiency . . . ." Levin, *supra* note 2, at 335. *See* SMITH, *supra* note 7, at 106; Katzenbach, *Address on Communications Satellite Legislation*, 7 ANTITRUST BULL. 421, 424-25 (1962) [hereinafter cited as Katzenbach].

[31] HASTINGS NOTE, *supra* note 29, at 734. See Sen. Russell Long's (D. La.) attack on carrier participation in which he characterized the bill as being "as crooked as a barrel of snakes." 108 CONG. REC. 1511 (1962).

A. *Ownership of Earth Stations*

"The earth station problem dramatizes the difficulty of using an established regulated industry, with a heavy fixed investment in old equipment, to introduce a new technology."[32] In the first years of operation, Comsat owned and operated the three existing earth stations.[33] When a request was made to construct another needed station in West Virginia, the carriers protested vehemently. The result was a decision by the FCC in 1966[34] to grant the carriers half ownership in the earth stations, thereby reversing a ruling more favorable to Comsat issued only 19 months earlier.[35] The Commission gave to the Earth Station Ownership Consortium, in which ownership of the earth stations was split equally between Comsat and the carriers, responsibility for "formulating overall policy and deciding on major investments, types of major equipment and location of new stations, and the establishment of arrangements for the day-to-day operations of the station."[36] This arrangement included shared management of the stations and control of the "local loops."[37] Thus, the major carriers apparently utilized their influence and power to cause a complete reversal by the FCC of its earlier decision. They claimed that ownership of the stations was necessary for them to contribute to the development of the art, yet their building activities, both domestic and foreign, should have been sufficient to supply the needed incentive. Their argument that a Comsat monopoly would be against the spirit of the Act had little basis, since the Act explicitly permits an earth station monopoly as one of the FCC's alternatives.[38]

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[32] Schwartz, *Comsat, the Carriers, and the Earth Stations: Some Problems with "Melding Variegated Interests,"* 76 YALE L.J. 441, 444 (1966-1967) [hereinafter cited as Schwartz].

[33] "The earth station is a large, dish-shaped broadcasting and receiving antenna aimed at a satellite orbiting 22,300 miles above earth." A message is sent via the earth station to the satellite, which relays the signal to another earth station near the point of destination. It is then sent from the receiving station by a "local loop." KINSLEY, *supra* note 2, at 27.

[34] Amendment of Part 25 of the Commission's Rules and Regulations with Respect to Ownership and Operation of Initial Earth Stations in the United States for Use in Connection with the Proposed Global Commercial Communication-Satellite System, 5 F.C.C. 2d 812 (Dec. 7, 1966).

[35] Amendment of Part 25 of the Commission's Rules and Regulations with Respect to Ownership and Operation of Initial Earth Stations in the United States for Use in Connection with the Proposed Global Commercial Communication-Satellite System, 38 F.C.C. 1104 (May 12, 1965).

[36] 5 F.C.C. 2d at 820.

[37] The local loops are the connections between the earth station sites and the common carrier facilities. For an excellent discussion of the earth station controversy see KINSLEY, *supra* note 2, at 26-46.

[38] 47 U.S.C. § 721(c)(7). In pertinent part, the FCC shall:

> grant appropriate authorizations for the construction and operation of each satellite terminal station, either to the corporation or to one or more authorized carriers or

The carriers' real concern was a threat to their present and projected rate base raised by an independent satellite system.[39]

By denying Comsat complete ownership of the earth stations, the FCC destroyed any real chance for competition in the communications industry. Under the FCC ruling, the carriers are able to participate in more decision making at the earth station level, where they have a sure veto and are unaffected by conflicting fiduciary obligations.[40] Comsat's independent control of the stations would have provided vigorous competition so as not to require such close regulation.[41] Instead, the FCC chose to protect the interests of the existing industry.

B. *Authorized Users*

Another major ambiguity in the Act which required resolution by the FCC involved the question of which users would be allowed to lease satellite circuits directly from Comsat. Many large users other than the participating major carriers wanted to lease long-term circuits directly from Comsat. The international carriers insisted that the Act was intended to protect their investments by granting them exclusive buying and selling rights.[42] The policy argument advocated by the carriers claimed:

> that the carriers, prevented by the Satellite Act from establishing satellite facilities, had to depend on Comsat for satellite circuits, and it would be inequitable to allow Comsat to provide the profitable leased channels

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> to the corporation and one or more such carriers jointly, as will best serve the public interest, convenience, and necessity.

See also Schwartz, *supra* note 32, at 456.

[39] With full ownership of the earth stations and the local loops, Comsat would be able to offer service fully equivalent to that of the international carriers. KINSLEY, *supra* note 2, at 37. The "rate base" system is used by the FCC to determine the amount of profit allowed, based upon investments in equipment.

> It is clear that in a monopoly situation, locked into a predetermined maximum rate of profit, a firm will have little incentive to eliminate unnecessary expenses. In fact, it will usually have a *positive* incentive to try to get away with unnecessary investments, because these will add to *its* rate base.

Id. at 31-32. This tendency to invest unwisely and excessively to expand the rate base is known as the Averch-Johnson effect. J. Dingell quotes from the General Services Administration:

> It is time to abandon the thesis that regulation is the law's substitute for competition. Even where monopoly is benign, it is dangerous for monopoly to make the decisions. Both friends and foes of the regulatory process acknowledge its limits in affecting incentives, promotion of economy and developing efficiency and optimum cost of services. Regulation is essentially negative. It should utilize competition as a powerful supplement.

Dingell, *The Role of Spectrum Allocation in Monopoly or Competitition in Communications*, 13 ANTITRUST BULL. 937, 943 (1968).

[40] Schwartz, *supra* note 32, at 476.

[41] "But the structure they [FCC] did create is so full of potential conflicts and opportunities for insider self-preference that constant policing will be needed." *Id.* at 483.

[42] KINSLEY, *supra* note 2, at 50.

> directly to the large users and offer to the carriers only the less desirable services . . . Comsat would offer services to users and to carriers at substantially the same rate, and this would prevent the carriers from reselling satellite service to users on competitive terms.[43]

The FCC seemingly agreed with this "cream skimming" argument and resolved the issue in favor of the carriers.[44] Once again the FCC administered a serious blow to the possibility that Comsat might serve as a competitive alternative to the existing communications industry.[45]

The FCC also forbade Comsat from leasing circuits directly to the United States Government despite explicit language in the Act authorizing them to do so.[46] The Commission concluded that the reference to the government was reserved only for unique and exceptional situations.[47] The Government tested this ruling less than a year later when the Defense Department approached Comsat concerning the leasing of 30 satellite circuits from Hawaii to the Far East to monitor the Vietnam War. The Commission ruled that the Government had to purchase the circuits from the carriers at a "composite rate."[48] As a result, internationally leased circuit rates remained abnormally high, inhibiting the growth of Comsat and discouraging the aim of the Act to provide a global service at reasonable rates.[49]

Looking back over the reports on the earth station and authorized users decisions, one cannot help but be struck by Comsat's timid objections and questionable concessions. In its annual reports to the President, Comsat has consistently failed to utilize its avenue of recommendation granted to it by the Act.[90] These failures on the part of Comsat can only point towards the inherent conflicts and self-preferences imbedded within its structure. The influence exerted by the carriers through their participation in the management of Comsat is more than apparent from this line of decisions. The result has been an even greater concentration of power in the existing communications carriers and the inhibition of any possibility of realizing a truly competitive system. Attention will now be turned to the international realm in order to see what impact the organizational structure of Comsat has had on the development of a global satellite system.

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[43] Acheson, *Competition Problems in International Communications*, 13 ANTITRUST BULL. 963, 966 (1968) [hereinafter cited as Acheson].

[44] Authorized Entities and Authorized Users Under the Communications Satellite Act of 1962, 4 F.C.C. 2d 421 (July 20, 1966) [hereinafter cited as Authorized Users].

[45] "Clearly, if there were to be unrestricted dealings of Comsat with the public, it would mean that Comsat would be using its monopoly position to the detriment of the other carriers and, indeed, to deprive them of the opportunity to serve segments of the public under fair and equitable conditions." *Id.* at 428.

[46] "[T]he corporation is authorized to . . . contract with authorized users, including the United States Government, for the services of the communications satellite system . . . ." 47 U.S.C. § 735(b)(4) (1970).

[47] Authorized Users, *supra* note 44, at 435. The Commission noted that "loss of a substantial proportion of Government leased circuit revenues could have serious adverse effect upon the carriers. Instead of being able to reduce rates to reflect the lower costs of satellite circuits, they would probably have to seek substantial rate increases." *Id.* at 434. The Commission also noted that the Government provides over 70 percent of total leased circuit revenues.

[48] The carriers were to provide both satellite and cable circuits at a composite rate of $7,100. The cable rates at the time were approximately $11,000 per half circuit and Comsat had offered direct service for $4,000 per half circuit. The Commission ordered Comsat to sell the satellite circuits to the carriers for $3,800. Acheson, *supra* note 43, at 968. "The net of this is that, at the direction of the FCC, the carriers' revenues from satellite service they sell pay a substantial part of the costs of the cable system." *Id.*

[49] In 1967 the international carriers were buying half circuits from Comsat for $2,700 a month and selling them to users for $8,000. KINSLEY, *supra* note 2, at 63.

IV. COMSAT'S DEALINGS ABROAD

The initial impetus for developing a global communications satellite system was a national challenge to be the forerunner in providing leadership in the peaceful use of outer space for the benefit of all mankind. "Here a successful program should pay dividends for us and other countries, not only in economic terms but also in terms of such important intangibles as the development of mutually helpful attitudes, institutions and relationships."[91] The Act expressly noted the need for foreign cooperation in the system[92] and consequently placed several controls on Comsat's ability to negotiate abroad.[93] This need for foreign cooperation resulted in numerous areas of conflict for Comsat during its formative years, in dealing with both the United States Government and foreign entities.[94]

V. THE EMERGENCE OF INTELSAT

The terms regarding participation in an international satellite system were not specified in the Act, in spite of the potential impact upon American foreign policy objectives. The need to formulate specific guidelines in order to insure effective negotiations with foreign nations was recognized immediately.[55] No sooner had the new corporation come into existence than it objected to the State Department's interference with its international policy planning.[56] Comsat officials envisioned the establishment of a system based on a series of bilateral agreements (similar to their cable arrangements) with the result that the United States would be situated in the "center of the web."[57] As an alternative, they desired an American owned system that leased out the circuits.[58] The State Department opposed these proposals and advocated a multilateral arrangement allowing for more flexibility.[59] The dispute was resolved in favor of pursuing a multilateral arrangement which would encourage foreign nations to participate in the use and ownership of the system.[60] Relations between Comsat and the State Department improved considerably following these initial differences, but Comsat's dealings abroad were destined to be plagued by conflicts.

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[90] 47 U.S.C. § 744(b) (1970).

[91] Katzenbach, *supra* note 30, at 423.

[92] 47 U.S.C. § 701(a) (1970). *See* Rand Memo, *supra* note 4, at 17.

[93] Schwartz and Goldsen include the following: 47 U.S.C. §§ 721(a)(4), 721(a)(5), 721(c)(3), and 742. Rand Memo, *supra* note 4, at 18-19. 47 U.S.C. § 742 is the basic provision for control over Comsat's dealings abroad. 47 U.S.C. § 721(c)(3) states that the FCC should require the corporation to establish communications with a particular country where the Secretary of State advised that such communication was in the national interest.

[94] Through the authority of the President to oversee relations with foreign governments (47 U.S.C. § 721(a)(4)), the State Department would control foreign relations and Comsat would control business negotiations, but the relations between these two remain uncertain. GALLOWAY, *supra* note 11, at 73. "Once the State Department classifies a particular problem as one of 'foreign policy,' it will no doubt insist on fulfilling its statutory role, even though the Corporation might prefer to handle the problem as a purely business matter." Rand Memo, *supra* note 4, at 19. For a discussion of these conflicts in the creation of a global satellite system, *see* GALLOWAY, *supra* note 11, at 82; Underwood, *Problems of Participation in the Global Commercial Communications Satellite System*, 18 S.C.L. REV. 796, 799-807 [hereinafter cited as Underwood].

A plan for an international communications satellite association was first conceived in October of 1963, at a conference of the International Telecommunications Union (ITU).[61] By July 1964, the negotiating countries had managed to resolve their initial differences and had agreed to the Interim Arrangements for a Global Commercial Communications Satellite System.[62] A month later the group officially established the International Telecommunications Satellite Consortium (INTELSAT).[63] The United States was able to dominate the shaping and control of INTELSAT from the outset, due to its superior technological expertise and its major role in the operation of international message circuits.[64] Comsat emerged as the general manager of the system and received 61 percent of the voting power based upon the volume of American use in the system.[65] This insured

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[55] SMITH, *supra* note 7, at 130-31.

[56] *Id.* at 131. Philip Graham, publisher of the Washington Post, was elected the first chairman but due to illness he was replaced by Leo Welch after only three months. Mr. Welch also attacked the FCC for its invasion in Comsat's managerial functions.

[57] Chayes, *Unilateralism in United States Satellite Communications* in THE INTERNATIONAL LAW OF COMMUNICATIONS 42, 45 (E. McWhinney ed. 1970) [hereinafter cited as Chayes].

[58] *Id.*

[59] SMITH, *supra* note 7, at 131.

[60] *Id.* at 135. The State Department attempted to overcome the differences by convincing Comsat that the Europeans urged a multilateral agreement and that they were serving as the chosen instrument of American foreign policy and not as a private enterprise. GALLOWAY, *supra* note 11, at 82.

[61] HASTINGS NOTE, *supra* note 29, at 739.

[62] Aug. 20, 1964, [1964] 15 U.S.T. 1705, T.I.A.S. No. 5646, 514 U.N.T.S. 26 (effective for United States Aug. 20, 1964).

[63] GALLOWAY, *supra* note 11, at 99. *See* McWhinney, *The Antinomy of Policy and Function in the Institutionalization of International Telecommunications Broadcasting*, 13 COLUM. J. TRANSNAT'L L. 3, 9 (1974) [hereinafter cited as McWhinney].

[64] SMITH, *supra* note 7, at 140-41.

[65] *Id.* at 138.

Comsat virtually complete control over the system during its formative years.[66]

Despite smooth functioning of both the space and ground segments of the system, Comsat was unable to deal effectively with the other foreign members. Dr. Reinhold Steiner, the only non-American fulltime, permanent representative to INTELSAT, said, "If you consider the interest of the U.S. in improving relations with other countries, Comsat has failed. Of all the international carriers, Comsat has the worst reputation."[67] Comsat's management of the system was criticized because it "wore 'three hats' at the same time—as a U.S. internal, domestic, common carrier for profit; as the U.S. national representative to INTELSAT; and, finally, as the general managerial authority within INTELSAT itself."[68] Much of this criticism may be warranted when one views the manner in which procurement of equipment and the handling of contracts was conducted. Only 5 percent of over $380 million spent by INTELSAT through the middle of 1971 was spent outside the United States.[69] In light of these figures one can easily understand why Comsat, the only privately owned carrier in INTELSAT, came under such critical attack.[70]

Due to Comsat's inability to generate goodwill within INTELSAT, the United States found it difficult to retain much of the power it formerly enjoyed when the Interim Arrangement was renegotiated. At the European Space Telecommunications Conference of 1967, the European nations agreed "on the desirability of removing Comsat as the system manager, restricting its voting power and developing separate, regional systems."[71] Meanwhile, under pressure from the State Department and the FCC, Comsat agreed to internationalize some management functions while retaining technical and operational control. The same major issues of 1964, *i.e.*, ownership quotas, voting arrangements, and management, were the principal areas of controversy in the Definitive Arrangements negotiations.[72]

After more than two years of negotiation, the Definitive Arrangements were finalized in August 1971, to become effective in February 1973.[73] The most important changes provided for a Director General to replace Comsat as the head executive over a 6 year transitional period. A Board of Governors was created to consist of approximately the top 20 investors. Comsat will continue to perform technical and operational services until 1979 under a management services contract.[74] Even after drastic reductions in Comsat's control, the other members further insured their control by requiring a two thirds majority vote by the Assembly of Parties (based on a one nation - one vote scheme) in order to decide substantive matters.[75] At this point, one can only speculate as to whether INTELSAT will continue to provide necessary services or if any future expansion in services will have to occur outside its framework.

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[66] Chayes, *supra* note 57, at 46.

> But the Interim Arrangements did not provide the conditions for the growth of confidence in the consortium as an international instrument responsive to the international community. Intelsat became, for the most part, an arena in which Americans and Europeans battled out and traded out parochial interests without achieving a larger vision of international communications requirements.

[67] KINSLEY, *supra* note 2, at 115.

[68] McWhinney, *supra* note 63, at 11.

[69] KINSLEY, *supra* note 2, at 119. Comsat was also accused of manipulating its managerial role for private purposes in procuring contracts for INTELSAT IV satellites. *See id.* at 122-26.

[70] "As a private company, Comsat has been less successful than an experienced government agency might be in dealing with foreign representatives." *Id.* at 115.

[71] SMITH, *supra* note 7, at 144.

[72] GALLOWAY, *supra* note 11, at 158.

VI. THE RESOLUTION OF AMBIGUITIES IN OUR FOREIGN OBJECTIVES

The developments over the past decade furnish one basis for determining whether the United States has been successful in establishing a global communications satellite system, as it had been originally envisioned. Due to the unique nature of the venture, there are several ambiguities in the Act which stem from foreign policy considerations. These include: (1) the urgency in establishing the system, (2) the meaning of "peace and understanding," (3) the nature of United States leadership, (4) the kind of participation by foreign countries, and (5) the relations between the Department of State and Comsat.[76]

The desire to establish a communications satellite system at the earliest possible time was primarily motivated by Russian success with Sputnik.[77] Since the technical knowledge necessary to develop a global satellite communications system was still several years away, the ownership issue should have been studied more carefully before enacting legislation which had the effect of circumventing the antitrust laws. The Act's goal, to stimulate all available talent and resources, was probably more hindered than aided by the grant of corporate control to the owners of an old technology with which the corporation was in direct competition. This hindrance did not appear to impede the establishment of an international consortium, since the United States government managed to manipulate the development of the consortium through its prescribed powers in the Act.[78] But as has been seen, the carriers did succeed in winning several decisions which resulted in keeping international circuit rates unnecessarily high.[79]

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[73] Agreement Relating to the International Telecommunications Satellite Organization "Intelsat," Aug. 20, 1971, [1972] 23 U.S.T. 3813, T.I.A.S. No. 7532 (effective Feb. 12, 1973).

[74] SMITH, *supra* note 7, at 151.

[75] *Id.* at 150.

[76] GALLOWAY, *supra* note 11, at 100.

[77] *Id.* at 47.

[78] One view states that the successful establishment of a global satellite system can be attributed to the government's approach of cooperation and participation toward Comsat. GALLOWAY, *supra* note 11, at 101-02. For example, the government achieved a cohesive and united position with Comsat in foreign negotiations. *Id.* at 105.

The Government's goal of achieving world peace and understanding has the appearance of failure in the early years of INTELSAT. Comsat's activities as manager of the international system were strongly criticized as being tainted by the carriers' private interests.[80] The decision to organize Comsat as Congress did, "meant from the outset that United States foreign policy objectives and perceptions in the field would be filtered through a private entity with divergent goals and perspectives."[81] The legislative history indicates that Congress failed to see the international ramifications of the Act. Speaking optimistically before the Senate Foreign Relations Committee, Secretary of State Dean Rusk said: "The fact that the corporation will be owned and the capital supplied by private companies and individuals will not impair the ability of the United States to cooperate successfully with other countries and international organizations in establishing a global communications system."[82] History now shows there was little difficulty in establishing the global system, but much controversy resulted from having a private corporation represent American foreign interests. Comsat's difficulties with the Government at home had an adverse effect upon its dealings abroad, where previously the international carriers had an excellent track record with telecommunications systems overseas.[83] As a result, the United States leadership role in the global system has been cut back substantially by the Definitive Arrangements revamping INTELSAT.

The current membership in INTELSAT indicates worldwide participation, with the exception of the Soviet bloc.[84] During the early years, the provision of services to the developing countries took place slowly, due to the immediate need to follow high volume routes in order to insure economic security. But today, almost worldwide services are available, and the smaller countries play a greater role under the new arrangements. On the other hand, participation by other nations in the manufacturing of components was severely limited in the early years, causing much discord among the members.[85] Hopefully, the improvement of technological capabilities among more countries, along with the change in INTELSAT's management, will remedy this problem.

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[79] Recall the earth station ownership decision, note 34 *supra*, and Authorized Users decision, note 44 *supra*.

[80] "Comsat's attitude has antagonized foreign governments and has been accused of slowing development of the international satellite system." KINSLEY, *supra* note 2, at 117.

[81] Chayes, *supra* note 57, at 44.

[82] *Hearings on the Communications Satellite Act of 1962 Before the Senate Comm. on Foreign Relations*, 87th Cong., 2d Sess. 173 (1962).

[83] HASTINGS NOTE, *supra* note 29, at 739.

[84] INTELSAT presently has 94 members and accounts for over 90 percent of the international communications traffic by satellite.

[85] SMITH, *supra* note 7, at 142. "In order to ensure that the U.S. aerospace industry remained the leader in technology development, the federal government placed controls on the exportation of technology likely to be applied to communications satellites." *Id.*

The difficulties resulting from the ambiguous role of the State Department became immediately apparent. The State Department's concern over foreign policy implications was demonstrated by its avid support of the President's original bill, which would have allowed the State Department to conduct or supervise the foreign negotiations of the corporation.[86] Despite several alterations in the bill which resulted in changing the State Department's role to an advisory one,[87] history now shows that this limited control was used in conjunction with the President's powers under section 721(a)(4) to control most of the foreign policy developments. This control over foreign policy by the executive branch supports the contention of Secretary Rusk that the bill provided the United States Government with adequate authority to protect our foreign policy objectives; however, the use of a private corporation to implement American plans caused more problems than expected.

The early controversies between Comsat and the Government concerning ownership, treaty arrangements, and management of INTELSAT illustrate the uncertainties prompted by ambiguities in the Act.[88] The Government's role during the early operating years of INTELSAT was limited so that it would not appear as if the United States was using Comsat's managerial role to shape the direction of the entire international consortium. Yet the State Department did not hesitate to intervene during negotiation of the Definitive Arrangements so as to insure compatibility with our foreign objectives. As a result of all this confusion, "neither the United States itself nor foreign governments or communications entities can know entirely who is dealing with whom and with what authority."[89]

VII. CONCLUSION

The history of the development of the international communications satellite system casts some doubt on the propriety of the choice that the United States made in 1962.[90] In its haste to create a global satellite system, the 87th Congress created a structure "which contemplates numerous interlocking directorates; creates a backward and forward vertical joint venture; and provides for substantial minority interests by companies which are simultaneously potential suppliers, customers, and competitors."[91] The potential for conflict which the Act created by granting control of the system to the existing major carriers soon became a reality during the resolution of several ambiguities inherent in this unique venture. The purpose of the Act, to reflect "the benefits of this new technology in both quality of services and charges for such services,"[92] was impeded by the carriers in their efforts to protect huge investments in undersea cables. Their successful lobbying efforts with the FCC resulted in the destruction of any possibility of Comsat serving as a potential competitor, thereby keeping internationally leased circuit rates unnecessarily high. Ambiguities in the Act concerning the various róles and objectives of the Government resulted in the existence of almost constant tension between Comsat and the State Department. This caused the United States to project a poor image in INTELSAT and appears to have achieved little in the way of world peace and understanding.

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[86] GALLOWAY, *supra* note 11, at 49. "From this, one can infer that the State Department foresaw the possibility that a private corporation controlling satellite communications might not always act in the best interests of the United States." *Id.*

[87] 47 U.S.C. § 742 (1970).

[88] GALLOWAY, *supra* note 11, at 82.

[89] Underwood, *supra* note 54, at 799.

[90] "The fact is that technological change in satellite communications brought a new order of complexity into communications policy. Technological change widened the area of choice and at the same time confused the old pattern of expectations. These consequences of technological innovation encouraged legislative decision-making and incrementalist rationality." GALLOWAY, *supra* note 11, at 104.

Despite all of these shortcomings which the first decade of operation has produced, the future years show hope for the development of a more productive global satellite system. The major carriers have now divested themselves of most of their ownership in Comsat, so there should be fewer inherent conflicts of interest within the organization.[93] Comsat should utilize its power to make recommendations to the President and Congress in order to stimulate greater legislative review. A reversal of some past FCC rulings could provide the incentive necessary for innovation by allowing Comsat to function as a true competitor. But so long as regulatory agencies such as the FCC are allowed to render decisions consolidating control of a new technology in the hands of the existing industry, there is little hope that the objectives such as those proposed in the Communications Satellite Act of 1962 will ever be realized.

Scott K. Socol

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[91] Schwartz, *supra* note 32, at 464-65.

[92] 47 U.S.C. § 701(b) (1970).

[93] "The major carriers, with the exception of AT&T, have all divested themselves of their shareholdings with the result that only AT&T is now eligible to nominate and elect carrier directors and, in fact, there are currently only three carrier directors on the Comsat Board, all of whom represent AT&T. Establishment of Domestic Communications-Satellite Facilities by Nongovernmental Entities, 38 F.C.C. 2d 665, 680 (Dec. 22, 1972).